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NASA AUTHORIZATION FOR FISCAL YEAR 1984

HEARING

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

NASA AUTHORIZATION FOR FISCAL YEAR 1984

MARCH 8, 9, AND 15, 1983

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NASA AUTHORIZATION FOR FISCAL YEAR 1984

TUESDAY, MARCH 8, 1983

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:40 a.m., in room 253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Peter Perkins, professional staff member, and Steven Flajser, minority professional staff member.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. I call to order this authorization hearing for National Aeronautics and Space Administration [NASA] of the Science, Technology, and Space Subcommittee of the Committee on Commerce.

The Congress recognized the dual civilian and defense of the Nation in space and aeronautics in establishing NASA in 1958.

Among the policies of the act was that aeronautical and space activities, and I quote:

> Shall be the responsibility of, and shall be directed by, a civilian agency * * * except that activities peculiar to or primarily associated with the development of weapons systems, military operations, in the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by the Department of Defense (DOD)."

In a less convoluted and more succinct fashion, the act's objectives for national aeronautical and space activities included: Making available to our national defense agencies "discoveries that have military value or significance"; and furnishing information to NASA from our national defense agencies about discoveries that have civilian mission significance.

The Committee on Commerce, Science, and Transportation has specific jurisdiction for "nonmilitary aeronautical and space sciences," which means in particular the authorization for NASA.

It is in the course of developing our fiscal year 1984 authorization for NASA and in recognition of the close relationship of our civilian and defense aeronautical and space activities that we are holding this hearing today.

This is the 25th anniversary of NASA. For most of that time our Nation has enjoyed preeminence in both aeronautics and space in both the civilian and defense realms.

In the last 2 years that I have been in the Congress the Space Shuttle has progressed from its stunning maiden voyae to an operational system. There is at this time no equal in the world to this unique capability for science, civilian applications and national defense. Our success has been a tribute to the balanced relationship which has been maintained between NASA and DOD.

We now face new challenges which require an appraisal of that relationship if we are to meet the competition in space, science and applications, in commercialization of space, and in the threat of militarization of space.

Our purpose in today's hearing is to review our national defense activities in aeronautics and space in order to determine how these impact or are impacted by the proposed fiscal year 1984 NASA program.

The issues of mutual concern are many: the composition of our national space transportation system; the requirements for a permanent manned space platform; the equitable support of space activities by our civilian and space agencies; the development of mutually appropriate upper stages for the space shuttle; and the continued advancement of both military and civilian aeronautics.

There can be no question that the decisions which are made in response to these concerns will be as difficult and critical as any which have been faced in the past. Certainly our position in aeronautics and space is more directly and aggressively challenged than ever before.

With these thoughts in minds, I am pleased to welcome to this hearing Dr. Richard DeLauer, Under Secretary for Research and Engineering in the DOD, and Dr. Robert Cooper, Director of the Defense Advanced Research Project Agency. Both of these gentlemen have appeared before this subcommittee previously and I welcome them here today.

Dr. DeLauer, we will be happy to hear from you right now.

STATEMENT OF RICHARD D. DeLAUER, UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE, ACCOMPANIED BY DR. ROBERT COOPER, DIRECTOR OF ADVANCED RESEARCH PROJECTS AGENCY

Dr. **DeLauer**. Thank you, Mr. Chairman.

We are happy to be here again. We always like to come before this committee and tell you how we are working together with NASA on areas that both Bob Cooper and I have a deep personal interest in, and that is the whole question of aeronautical research and space research in this country.

I have a formal statement and I would like to ask your permission to submit it for the record, summarize it briefly and then let you ask us some questions.

Senator **Gorton**. Your full statement will be included in the record, and you may proceed to summarize.

Dr. **DeLauer**. As mentioned in your opening statement, DOD and NASA have a strong working relationship, not only in the basis of our organizations, but personally. Hans Mark and Jim Beggs and the people in NASA are colleagues of long standing, and we have a very comfortable relationship with one another. We talk to each other on many subjects and as a consequence, I think that we get to the heart of the issues very quickly.

Just to reiterate, you know we do have quite a few joint efforts going on right now. The shuttle is certainly the most important, but we are collaborating on Centaur G. The work we are doing at Vandenberg, which will benefit both DOD and NASA, is continuing. Then one of the more exciting advances in aeronautical research is the advanced fighter technology integration program at Edwards, which is a joint program. It is kind of exciting to see the Air Force, Navy, and NASA, all of us together out there working on that particular project.

If you have an interest in it, the committee ought to take time to go out and take a look at it. It is quite an airplane. That is if you can believe an airplane will rotate about a center without banking, will translate, will go up and down without pitching, it is quite a sight. The pilots that fly it say it is sure a different world than they have been used to. But it is an exciting program and I think a lot is going to come out of it.

Under Bob's direction and leadership, we are proceeding with the forward swept wing advanced development demonstrator up at Grumman. I was up there a week or so ago and the first one is in final assembly. Since we had some pieces and parts around, we decided to complete the second one, and that is well on its way in final assembly.

The JVX program is one that we are proceeding to work together on. This is the tilt rotor concept. The program has some programmatic problems within DOD because being a joint program, you know, you start about 10 yards behind the starting line. This happens because what is high in one service's priority list isn't high on another one and the job is to make them all see the light.

I am very proud of the fact that I have a memorandum of understanding framed on the wall of my office signed by the three Service Secretaries on the JVX program. I have to admit that that particular memorandum of understanding has a half life of about 90 days.

So we are in the process of still struggling in the light of some economic affordability issues between the Army and the Navy particularly.

But the interaction with NASA continues. We work very closely with their centers and with our R&D labs. We have a committee that meets about four times a year, a board which is cochaired by Hans Mark and myself. While we missed this year's first meeting because of the snow storm, we are going to have it at the end of the month primarily for the purposes of being sure that we know what the action items are and we have the right people working on them. In the past these meetings have pretty much emphasized the Shuttle, but this year we are looking at some of the aeronautical issues.

In keeping with the interests of this committee on how things are going in space with our adversaries, I have included a reasonably detailed summary of the Soviet space activities.

Let me just briefly recap that. I would best characterize it by the fact that it is large. It is ambitious and they know the value of space, both for military purposes as well as political propaganda, and they have done an awful lot of work. 1982 was a big year for Soviet space activities. I will not mention the details of their launch activity, but they cover the full spectrum: antisatellite interceptors, which they test operationally, radar satellites for the purpose of sea surveillance, a full array of the photo and electronics intelligence payloads, both for strategic and tactical applications. They have essentially an early warning, a missile detection capability, as we do, and of course they are expanding their communications satellite activity.

They are extending their military satellite network to include, as are we, navigation and meteorology as well as weapons support activities. Their manned program has continued without any real slacking off. They have focused on space stations and space station modules and ferrying cosmonauts back and forth to it and have been very successful.

In 1982 the Soviets had a record high of [deleted] attempted space launches placing [deleted] payloads in orbit. A very ambitious program. Their rate reflects the large number of programs and expansions and capability to support their military forces.

On any given day 70 to 110 Soviet satellites are in active use to support military forces. Development continued in 1982 on some new capabilities for them. Two new space boosters, one, a heavy lift vehicle in the Saturn 5 class, second, a medium lift vehicle, [deleted]. Reusable transport systems, one, a U.S. shuttle type orbiter, which we assume will be operational in the mid- or late-1980's, and then another small space plane, with a [deleted] assessment as probable operational deployment.

[Deleted.]

The RORSAT activity, I mentioned, [deleted].

They contine to power their RORSAT with nuclear reactors. They had problems with Cosmos 1402. It made the front pages but they will likely continue to use nuclear reactors in space. I don't think we are going to deter them one bit by the fact that they had the problems with that particular system. Since they have the ability to be able to break it up into two major components, if they have problems with it, they are just going to go ahead with that design. I don't see them doing an awful lot to change it. They are going to accept the risk.

You know they went 211 days in a manned space station. It is a new record in extended missions. One of the things that bothers me probably the most is the fact that they have launched the lifting body type reusable space craft designated Cosmos 1373. [Deleted.]

DOD SPACE ACTIVITIES

We requested $9.3 billion for this authorization for the 1984 budget. This is above the $8.5 billion that Congress gave us in 1983. We are increasing the size of the DOD's space budget and the cause is by many factors. One of them has been the increase in cost of DOD's portion of the Shuttle launching. As you might be well aware, we have just finished renegotiating the user fee and, like everything else, the price of transportation has gone up. Just at the time that fuel costs are coming down in the rest of the world, DOD is ending up paying more money to put payloads into space. But I think it was a proper thing to do. I think it is more equitable with what NASA has incurred for the launches. So we are proceeding to do all our planning on this higher user charge.

We strongly support the President's policy on maintaining the orbiter production and we will continue to do that.

I have talked about the repricing. We are in the process of completing construction for the Vandenberg operations. That cost us more money than we had intended. We are proceeding with our program for the consolidad Space Operation Center (CSOC) in Colorado Springs. We think with Completion of the CSOC that we will overcome some of the objections that Joint Chiefs of Staff have with existing limitations on the satellite operational capability that now exists.

We need a secure environment in which to conduct DOD space missions and we think that the CSOC will do that.

There have been a number of inquiries by Congress concerning the adequacy of the CSOC planning and the way we are procuring our equipment there. Let me assure you that we are trying to be prudent and have the best management possible to be sure that we have the right equipment in that system, that we will not duplicate obsolete equipment, as has been alleged. We intend to have a reasonably complete system development concept rather than providing government furnished software and then just trying to assemble the system. We will go out with the request for proposal on the shuttle operations and planning center probably in a little over a year from now.

We expect the satellite mission control center to be operational in 1986 and we are strongly committed to the Shuttle.

Now a brief word about our aeronautical activities. The budget for research development, test and evaluation for aircraft and related equipment in DOD in the 1984 submission is $4.1 billion. Of this about a half a billion dollars is devoted to aeronautical technology development, which is a portion of our program most closely alined to NASA.

We are continuing to explore the benefits of an integrated flight fire control concept on a modified F-15.

We are joint with NASA, as I mentioned before, on the advanced fighter program, which is in an airframe of an F-16. That is the one I urged you, if you have time, to take a look at.

The JVX of course is the advanced concept on tilt rotor. We are also carrying out in ARPA a strong program on an advanced X-wing configuration rotorcraft concept. We have a program where we will fabricate and test an X-wing rotor combination.

Propulsion is another area that we are working on and we are looking at opportunities for potentially a 15- to 20-percent increase in thrust and about a 15-percent reduction in fuel consumption and we hope we can have a reduction in some of the other aspects of the design.

We have tested carbon-carbon exhause nozzle liners and it looks like we can get over 300 hours in such a nozzle liner for an F-100 engine. That has some high hope for some of the advanced materials in lightweight engine development.

Our work in metal and matrix composite materials continues and we have a few demonstration projects being initiated that should come to fruition in the next year or two.

We participated extensively with the White House, with Jay Keyworth, on a study to establish a U.S. policy on aeronautical research and technology for the 1980's and 1990's and that study was completed in November 1982 and we continue to support it.

With these highlights, Mr. Chairman, why don't I turn it back to you and let you and the other members ask Bob and me some questions that are more germane to what you think would be best served for us to answer.

(The statement follows:)

Statement of Richard D. DeLauer, Under Secretary of Defense for Research and Engineering, DOD

INTRODUCTION

Mr. Chairman and members of the subcommittee, I am pleased again this year, as on previous occasions, to review the Department of Defense's programmatic relationships with NASA in space and aeronautics activities. I will address those programs in which we work jointly with the National Aeronautics and Space Administration and highlight our activities that are otherwise complementary. In keeping with prior interests of this committee, I will begin by briefly describing recent Soviet activities in space to provide perspective for our own programs.

SOVIET SPACE ACTIVITIES

The expansion of Soviet space programs and capabilities continued unabated in 1982 with [deleted] attempted space launches that placed [deleted] payloads into orbit. This high rate, which we expect to continue in the 1980's, reflects not only the large number of programs, but expansion in scope and capability of these systems for the direct and indirect support to Soviet land, sea, and air forces. On any given day 70–110 Soviet satellites are in active use to support military forces. Development continued in 1982 on new capabilities: Two new space boosters, one a heavy lift vehicle in the Saturn V class and the second a medium lift vehicle, [deleted] reusable transport systems, one a U.S. shuttle type orbiter and the other a smaller space plane; and large permanently manned space station complexes. The heavy lift vehicle we project would be launched in the 1985–1987 time frame and be capable of lifting 220,000 to 330,000 pounds into low earth orbit. By comparison the U.S. space shuttle can lift approximately 65,000 pounds into low Earth orbit. This large booster could be used for placing large space stations in orbit, for supporting manned lunar/planetary exploration, and for orbiting very large weapons. A variant of this vehicle would be used to launch a large shuttle craft in the late 1980's, and provide the Soviets with capabilities similar to our own space shuttle. A smaller space plane could be launched in the [deleted] time frame. It will probably be used to ferry cosmonauts to manned space station to conduct independent reconnaissance and satellite inspection [deleted]. The Soviets have continued to expand at an increasing rate their research, development testing and evaluation facilities, production and manufacturing plants, launch facilities, and space mission control network to support this large space effort.

Soviet military space capabilities include an anti-satellite interceptor, operational since 1971 and effective against low altitude satellites; platforms which provide space-aided weapons delivery against U.S. naval carrier forces; a full array of photo and Elint reconnaissance satellites for covering strategic and tactical targets; a missile launch detection capability against U.S. ICBM fields and test facilities; an expanding communication satellite systems for support to Soviet leadership, military and intelligence entities; and several military satellite networks for navigation, meteorological, and weapons system R&D support. Perhaps the most unique feature of the Soviet program, and one which has military potential, is their manned program. The program consists of a space station, space station modules, and ferry spacecraft for cosmonauts and equipment to sustain long-term manned missions. The trends and momentum of the Soviet space program for the past 25 years reflects a commitment to develop and deploy space capabilities that enhance and project military power. I will now discuss some selected highlights and noteworthy developments during 1982.

During 1982 the Soviet Union conducted an operational test of the radar equipped co-orbital interceptor as part of a large armed forces exercise. [Deleted].

Key elements in Soviet surveillance [deleted] are the ocean reconnaissance platforms, the Elint Ocean reconnaissance satellite (EORSAT) and the radar ocean reconnaissance satellite (RORSAT). These satellites provide detection and targeting data to Soviet surface vessels and submarines equipped with anti-ship weapons. The Soviets launched [deleted] EORSATs, which detect electronic emissions, in 1982. RORSAT activity was, however, the [deleted]. The Soviets continue to power the RORSAT with a nuclear reactor, but problems occurred with Cosmos 1402 reminiscent of the 1978 Cosmos 954 incident when it failed to boost its reactor into high storage orbit at the end of its mission. We expect the Soviet will continue, however, to maintain ocean surveillance satellites at high similar levels of operational activity in 1983.

The large and extensive photo and Elint reconnaissance program accounted for the greater part of the Soviet launches in 1982. [Deleted].

[Deleted.]

During 1982, the Soviets completed the Salyut 6 space station mission and launched and subsequently manned its replacement, Salyut 7. The combined Salyut-6/Cosmos 1267 space station complex was purposefully deorbited and destroyed as it entered the atmosphere on 29 July 1982. The 42,000 pound Salyut space station had completed well over four and one-half years in space. Salyut 7 was launched on 19 April from Tyuratam and was manned by a primary crew, cosmonauts Berezovoy and Lebedev, from 14 May through 10 December. This flight was 211 days in length and created yet another new record for mission duration. Salyut 7 was visited by two crews consisting of three cosmonauts each. The first crew contained a Frenchman, and the second crew, the second female cosmonaut. [Deleted].

The Soviets launched three Molniya 1 communications satellites in 1982 to maintain the eight satellite network that became operational in 1976. Two Molniya 3 satellites were launched to maintain the four satellite network now used to support civil and military communication relay. The Soviets also successfully launched one Raduga satellite into geostationary orbit to relay both civil and military communications. Two Gorizont geostationary platforms were also launched and support domestic and international communications. Two Ekran television broadcast satellites were also launched to provide service to the Far East.

[Deleted.] The Soviets also launched the first three developmental satellites in their navigation satellite (Glonass) program. Glonass will be the Soviet counterpart to the U.S. global positioning system (GPS) and has the potential to replace the NAVSAT-2 and NAVSAT-3 networks. The Glonass network will consist of 9-12 satellites. Meteorological networks were maintained with two launches. There were no scientific satellites launched in 1982.

On 3 June 1982, the Soviets launched a lifting-body type reusable spacecraft, designated Cosmos 1374. The primary mission of this subscale test model was probably to evaluate the aerodynamic performance of a reusable manned space plane.

DOD SPACE ACTIVITIES

To maintain the security of the United States, the Department of Defense acquires and operates space systems and pursues advances in related research and technology development. During 1982, new focus was provided for Department of Defense space systems. On June 22, 1982, the Secretary of Defense approved a statement of policy to guide the space-related activities of the Department. The DOD space policy is in furtherance of the national space policy announced by the President on July 4, 1982, and is fully consistent with and supports the principles underlying the United States space program. The DOD space policy directs the continued maintenance of a strong technology base with leadership in those areas necessary for effective national security. The policy recognizes that since a number of military missions in both peace and conflict can be very effectively supported by space systems, future military use of space, including such functions as command and control, communications, navigation, environmental monitoring, warning, surveillance, and space defense, should have an operational orientation.

As noted, Soviet development of an operational anti-satellite (ASAT) capability presents the potential for space to become a hostile environment. Therefore, the DOD space policy directs that military space systems, including essential ground elements as well as orbiting spacecraft, be designed, developed, and operated to enhance the survivability and endurance of critical mission functions. Within limits imposed by international law, the policy directs development of a U.S. operational ASAT capability to deter threats to our and allied space systems and threats from space systems supporting hostile military forces. The policy contains no new directions in space weaponry, but provides for continued research and planning.

Space launch is critical to any space capability and the policy requires the availability of an adequate launch capability to provide flexible and responsive access to space to meet national security needs. The shuttle is recognized as the primary space launch system, and the need for continued cooperation with NASA to develop a fully operational space transportation system is acknowledged.

In a separate, but related action, the Air Force consolidated its management of space activities through formation of a new major command, space command, on September 1, 1982. Headquartered in Colorado Springs, space command will be built around the existing aerospace defense center staff.

The Air Force also created within Air Force Systems Command (AFSC) a space technology center at Kirtland AFB, New Mexico, in October 1982. Under this realignment, three AFSC laboratories, the Air Force Rocket Propulsion Laboratory, the Air Force Geophysics Laboratory, and the Air Force Weapons Laboratory will constitute the elements of the space technology center under the Air Force Space Division. This realignment will better meet the unique technology needs of space systems. The center will focus on the major scientific disciplines for launch vehicle and spacecraft technology.

To continue the momentum of achieving technically superior systems with enhanced operational characteristics (with particular emphasis on survivability) we are requesting $9.3 billion for Department of Defense space programs in fiscal year 1984. This represents an increase of 9.4 percent (real year dollars) over the corresponding $8.5 billion appropriated in fiscal year 1983.

As requested in your letter of February 18, to Secretary Weinberger, I would now like to focus on development, operation, and future plans for the space transportation system and related space activities of joint NASA/DOD interest.

Since I last addressed this committee, we have witnessed the completion of the highly successful space shuttle orbital flight test program, and we have experienced a nearly flawless flight on the shuttle's first operational mission, STS-5. Based on this demonstrated performance, we can now look forward confidently to a new national capability that will significantly affect our future space activities. That is not to say that we have answered all the questions or have overcome all the troublesome areas typical of any such complex program, but we are generally pleased and encouraged with progress to date.

We in the Department of Defense make extensive use of space systems to support national security operations, and that use is increasing. Fundamental to our capability in space is a responsive and affordable means of delivering payloads into orbit. Both our policy and our plans recognize the shuttle as the primary space launch system for national security payloads, and our concern for the viability of the shuttle program is obvious.

As I have noted, we have been very pleased with the shuttle's flight test program and its highly successful first operational mission. We are justifiably proud of the design, development and progress to date, but recognize that additional significant achievements are required to make the system fully operational and responsive to DOD requirements.

Thus far, the fastest turn-around for a shuttle launch was for STS-4 which took 78 workdays for system preparation with additional experience and maturing of the system hardware, this turn-around time should decrease appreciably. Indeed, this turn-around must decrease in order to increase the shuttle launch rate which is key to achievement of a responsive and economical operational system.

We remain concerned about the shuttle's capability to launch payload weights that were specified in the early days of shuttle development and which provided the basis for payload design decisions. We have some national security payloads being developed which are close to the latest maximum shuttle payload capability projections provided by NASA. Reductions in orbiter payload weight capability could cause significant problems and result in major delays and cost increases for some of the Nation's most critical space systems.

We are closely monitoring the schedule slip of the upcoming flight of STS-6 (the first shuttle launch of the inertial upper stage and the first tracking and data relay satellite) because of the operational demonstration it will provide as well the possible effect on the near term shuttle launch schedule. While we do not believe the currently projected slip on STS-6 to late March will delay our first DOD operational launch on STS-10 scheduled for November 1983, it does cause some uneasyness regarding the shuttle's operational capabilities during its early operational period.

The current problems with the main engines are troublesome and disruptive, but I believe they are part of the learning process associated with bringing any new, complex system into operation. These same problems also emphasize the DOD's longstanding concern for the adequacy of logistics support for the shuttle. Time and experience will improve our ability to predict the number and types of spare parts required, but it is clear from our current experience that our spares posture is tenuous to inadequate. Fortunately, the current slip in schedule happens as we are building to our planned launch rate. Such a protracted delay later, when our planned flight rate is much higher, would be far more serious.

On the recurring question of the ultimate number of orbiters, with just five STS flights to date, I do not believe there is adequate data to make a reasonable and confident decision on orbiter fleet size. As additional flights are made, we will be able to assess more fully such critical factors as turn-around time, system availability, maintenance, attrition, and demand. Prudent management dictates that STS production capabilities be maintained until we have made sound assessments of all these critical factors. To constrain ourselves prematurely to a four orbiter fleet could erode confidence in the STS as a dependable space transportation system. Both United States and foreign commercial customers must be able to view the STS as a dependable means to satisfy firm launch schedules. Significant launch delays translate rapidly into economic penalties that are particularly important to commercial users. It is important that the STS be operated as it was conceived making it highly dependable with competitive costs as rapidly as possible. Thus I strongly support the President's policy on this issue. This means that we should maintain the orbiter production base to include such items as wings, mid-bodies, and crew modules. If a four orbiter fleet continues to meet the aggregate demand, these components can be used as modular spares. However, if demand or circumstances dictate additional or replacement orbiters, the production base will be in place to support this procurement under efficient conditions.

In a related area, I note that the Air Force has renegotiated shuttle user charges with NASA. The new price of $29.8 million after 1985 (in 1975 dollars) has been incorporated in our fiscal year 1984 FYDP. This upward adjustment from the previously agreed to price of $12.2 million per flight was made to accommodate cost increases experienced by NASA. The key element of this agreement was the determination of a fair charge for DOD launches. Under this new agreement, the DOD will pay the same price per launch as commercial and foreign users for equivalent service, excluding manpower charges which will be traded between the Air Force and NASA. This agreement recognizes the interest of this committee in keeping the shuttle adequately supported without undermining other elements of the NASA budget.

Part of DOD's participation in the national shuttle program is the development of shuttle processing, launch, and landing facilities at Vandenberg AFB, California. This development is proceeding toward a first launch in October 1985. This west coast space shuttle facility will permit civil and government shuttle users access to polar and near-polar Earth orbits. Polar orbits cannot be reached from the Kennedy Space Center launch site without significant performance loss necessary to avoid overflying densely populated areas.

Vandenberg shuttle launch and landing construction was started in fiscal year 1979 with substantial modifications and additions to a launch pad that was built for the canceled manned orbiting laboratory program. A number of major construction projects are underway. These consists of facilities needed to store and process the orbiter, the external tank, the solid rocket boosters, and the payloads during prelaunch assembly and checkout activities. Also included are off-line engineering, data processing, and logistics support facilities. Construction is about 80 percent complete. The shuttle assembly building construction project awarded this past January is the last time-critical, major facility construction effort. This construction is on the critical path for an October 1985 IOC.

With many of the major buildings and facilities having been constructed, the major efforts have now transitioned to equipment and systems installations. This is the critical phase of the development program and will require the best efforts on the part of the Vandenberg team to meet the schedule. We have devoted significant attention to the Vandenberg program and have an able and competent team managing it. We believe that the Vandenberg construction will be completed on the schedule required.

This critical need for Vandenberg combined with mutual NASA/DOD interest in assuring the most economical operations possible, prompted the NASA and the Air Force to join together in requesting industry to propose a single shuttle processing contract for both coasts. This single contract approach will not only provide for healthy competition but will also give the winning contractor team maximum flexibility to earn incentives being offered for increased efficiency and reduced costs. This is only one of several positive signs of the maturing of the STS program. All in all, we are pleased about the progress being made at Vandenberg.

As I stated, the Vandenberg launch site is used for spacecraft requiring polar or near-polar orbits. Most of these spacecraft will be placed in low-earth orbits wherein most of the shuttle payload capacity is translated into spacecraft payload on orbit. The Kennedy launch site is used to launch spacecraft requiring lower inclination orbits including all of our geosynchronous and other high altitude spacecraft. Since these spacecraft require altitudes greater than those achievable by the shuttle. A boost propulsion stage must be used to place the spacecraft in the desired orbit. Use of this boost stage, which must be considered as part of the shuttle payload, results in a significant reduction in the spacecraft weight that can be placed in higher altitude orbits.

These shuttle compatible upper stages are critically important to the amount of payload that can be placed in higher orbits. In examining national security upper stage requirements last year, it became apparent that the inertial upper state (IUS) was close to the margin required to meet the near-term projected weight needs and that a higher performance upper stage would be necessary by the late eighties. When NASA was directed by Congress, during the fiscal year 1983 review process, to develop an STS compatible centaur upper stage to launch its Galileo and international solar polar missions, we decided that a joint development program between the DOD and NASA would be in the Nation's best interest. Thus, NASA and the DOD will cost share the basic development program, called Centaur G. NASA will fund required modifications for the shuttle and launch pad as well as fund a stretched version of the stage called Centaur G prime. Under this agreement, two Centaur G vehicles will be provided to DOD to meet our 1987 and 1988 mission needs. A third spacecraft program, already integrated to the IUS will transition to the Centaur as part of a planned spacecraft block change in the late 1980's. Our remaining spacecraft programs will remain on the IUS at least for the near-term since these spacecraft are not scheduled for block changes until the early 1990's and earlier transition to Centaur would be too costly. I believe this upper stage strategy or continuing the IUS program while transitioning certain programs to the Centaur gives us the flexibility and capability needed to meet our future mission requirements.

Moving toward the ERA when the Department of Defense will plan and control national security shuttle missions, we are proceeding with our program for the consolidated space operations center to be located at Falcon Air Force Station, Colorado—A site in the vicinity of Colorado Springs. The CSOC is comprised of two elements, the satellite operations complex (SOC) and the shuttle operations and planning complex (SOPC).

The need for the satellite control capability is based on the vulnerability of the Satellite Test Center in Sunnyvale, California, a single node in the satellite control network which provides tracking, telemetry, and command capabilities to satellites supporting various national security missions. The STC is vulnerable to both environmental and man-made threats and has limited growth potential.

The need for the shuttle control capability stems from the planned reliance on the shuttle as the primary launch system for national security space missions. The DOD shuttle control capability at Johnson Space Center does not meet all DOD requirements for planning and conducting DOD missions. The annual capacity at JSC to conduct classified missions is limited, security is limited to secret, and military and civilian space operations are intermingled. JSC is also a single node, subject to hostile actions and environmental hazzards. CSOC overcomes these limitations by providing a secure environment from which to conduct DOD space missions, siting to minimize environmental and man-made threats, adequate capacity to support the national shuttle traffic model in concert with JSC, and the capability to conduct military space operations from dedicated DOD facilities allowing close coordination of shuttle and satellite operations.

The CSOC will become an integral part of the Air Force satellite control network.

There have been a number of inquiries by the Congress concerning the adequacy of CSOC planning and selection of the computer hardware and software. Although the distinction is not usually made, these inquires are directed at the SOPC portion of the CSOC, since the hardware and software for the satellite operations complex on the CSOC will use the same elements as those being incorporated in the competitively procured data systems modernization project of the satellite control facility. This equipment is on current configuration and the software is being produced using ADA design standards.

With respect to the Shuttle operations and planning complex portion of the CSOC, the allegation is that the hardware and software will duplicate "obsolescent" equipment and software at JSC. This view inaccurately assumes that the requirement to duplicate JSC functions necessarily implies duplicating JSC software and hence, JSC hardware. In reality the Air Force intends to compete the SOPC as a system development rather than providing Government furnished software and only competing the hardware whose selection could otherwise be largely preordained. The request for proposal, which is planned to be released in 1984, will offer potential bidders that use of JSC software and they may elect to bid on that basis. However, the system specification for CSOC lists several criteria for determining if use of JSC software is justified. They are: Risk (technical, schedule, and cost), acquisition cost, life-cycle cost, equipment availability, compatibility with JSC systems, operating efficiency, differences in operations concepts between the Air Force and NASA, and commonality and interoperability within the CSOC. If an innovative bidder shows a significant life-cycle cost savings in combination with acceptable technical and schedule risk, that proposal will be favorably considered whether or not it includes extensive use of JSC shuttle software.

The joint Air Force/NASA SOPC requirements definition study will be completed this year, followed by competitive system design contracts to be awarded in late 1983, and a system acquisition contract award in the fall of 1984. We plan to begin facility construction this summer following contractor selection in early May. We envision the first satellite mission control center to be operational in late 1986 with the shuttle planning element operational a year later.

The CSOC development schedule is designed to take full advantage of the intervening time to conduct a prudent and deliberate SOPC program to include planning, competitive source selection, procurement, development and operational testing, and training for operating personnel. We are working closely with NASA in all these endeavors.

As you know, the President on July 4, 1982, announced a national space policy which reaffirmed the space transportation system as the primary space launch system for both national security and civil government missions. That policy emphasizes that our first STS priority is that it become fully operational and cost-effective. The policy also provides, for continuation of expendable launch vehicles until we have confidence that the demonstrated capabilities of the STS are able to meet all the schedule and performance requirements of our national security spacecraft.

The DOD strategy for transitioning payloads to the shuttle is consistent with this national policy and calls for acquisition of sufficient backup Titan vehicles to ensure a launch capability for our critical DOD missions. Our current policy was approved several years ago and provides for expendable launch vehicle (ELV) backup for the first two years of shuttle operations from the Kennedy launch site. The backup capability will be provided by the newly developed Titan III(34)D boosters.

DOD's strong commitment to the STS is evidenced by a defense budget for Shuttle development, operations and related costs (Titan backups, CSOC, and payloand transition) which exceeds $15 billion dollars through fiscal year 1988. DOD planning for the shuttle includes the transition of all national security spacecraft from their current expendable launch vehicles (Titan, Atlas, Delta) to the Shuttle by fiscal year 1989. With the exception of one program (DMSP), the transition will actually be completed by the end of fiscal year 1986. Through fiscal year 1987, the DOD has reserved 14 of the first 70 shuttle flights as dedicated missions for DOD payloads and will share the equivalence of 3 more. I emphasize that in some critical programs we have already optimized our spacecraft for the Shuttle and as such, we can no longer fly these on current expendables; thus the Shuttle has now become a truly essential element of our national defense posture.

All in all, our transition plan is working well. We developed the Titan III(34)D to provide a common booster for all of our payloads to use—both at the east and west coast launch sites—during the transition period. We also developed the IUS to provide a common shuttle and ELV compatible stage so shuttle backup could be readily achieved. The first launch of the Titan III(34)D/IUS combination took place in October 1982 and placed both satellites into extremely precise mission orbits. We expect the IUS will provide similar performance with the NASA tracking and data relay satellite on STS-6.

We are nearing the decision point regarding continuing the Titan production program. We will decide, following STS-6, if shuttle performance will meet our essential national security needs. If STS-6 is successful, we would plan not to proceed with long-lead procurement of material for the 17th and 18th Titan III(34)D vehicles. Such action would end DOD procurement of the Titan since we would have an adequate number of Titan vehicles built or in production to meet our launch needs through the shuttle transition period.

There is considerable U.S. private sector activity including major aerospace firms, to obtain approval for the commercial production of expendable launch vehicles (ELV) and the provision of commercial launch services based on the commercial ELV's. The administration currently has the ELV commercialization subject under study including detailed policy considerations. There could be benefits to the Nation which may warrant our support of ELV commercialization, such as limited shuttle backup without continued Government investment as well as the potential for the United States to capture a greater share of the commercial and international market. We harbor some concerns, however, such as the adequacy of continued DOD launch support with both Titan and Atlas/Centaur vehicles through the period prior to shuttle transition and the potential impacts—both positive and negative—of additional launch alternatives on the shuttle program.

Looking toward the future, we are now examining DOD requirements which might be accommodated more effectively by a permanent manned presence in space. We are actively participating in the NASA space station activities and working with eight contractors in studying space station needs, attributes, and architectural options. We are also an active participant in the senior interagency group (SIG/space) space station working group which is addressing the policy issues which must be identified and resolved in order to establish the basis for an administration decision on whether to proceed with development of a permanently based, manned space station. In addition, the Air Force Scientific Advisory Board (SAB) has recently initiated a study of the potential military utility of a manned space station. The SAB will provide an independent appraisal of the potential military utility of a possible national space station to assist in our determining the appropriate level, if any, of DOD participation and involvement in the program.

Mr. Chairman, I would like to address one other issue that continues to be raised with increasing frequency. There is a misperception that somehow the United States is "militarizing space." The evidence usually cited is the size of the DOD space budget in comparison to NASA. Nothing could be more misleading.

Larger space budgets are dictated by many factors—such as the one billion dollar increase in shuttle launch charges which DOD must reimburse NASA over the next few years. Aside from that, we have discovered that doing business in space is just more cost effective for many support functions. Space-based platforms have a distinct competitive edge in satisfying DOD needs in areas such as communications, meteorology, warning and surveillance. To the extent that space-based systems present the most efficient way to perform these missions, that is where we apply our resources.

Mr. Chairman, I believe our space efforts provide an enhancement of our national objectives of deterrence of hostilities and a more peaceful, stable, global environment.

DOD AERONAUTICS ACTIVITIES

I would now like to discuss our activities in the area of aeronautics technology. For fiscal year 1984, the Department of Defense research, development, test and evaluation budget for aircraft and related equipment is approximately 4.1 billion dollars. Of this amount, $445 million is devoted to aeronautics technology development, which is that portion of our program most closely aligned to NASA activities. I will review our more important programs in aircraft flight control, propulsion, structures and rotary wing technology.

A major focus of our aeronautics technology program is to increase the combat capability of tactical aircraft through advanced control concepts. In that regard, we are continuing to explore the benefits to be derived through the application of integrated flight-fire control on a modified F-15B test bed aircraft. Through this integration of the aircraft flight control, fire control and weapons systems, the pilot is able to fly to a predetermined position for optimum weapon launch for either air-to-air or air-to-ground weapon delivery. Combat capability and survivability is enhanced, not only through increased weapon delivery accuracy, but also by the ability to fly highly evasive maneuvers in the terminal area. The results of the program have consistently shown significant increases in gunnery and bombing accuracy, as well as reduced firing times. The highlight of the program was the destruction of a QF-102 drone under maneuvering flight conditions, in September of last year.

In a related joint Air Force/NASA program on advanced fighter technology integration, an F-16 aircraft has been modified to provide the capability to idependently control aircraft translational and rotational degrees of freedom about each axis.

This results in unique maneuvering capabilities. The aircraft will be able to move up, down, or sideways without rotating: or, it can rotate about any axis: or, maneuver using any combinations of these motions. Coupling this unique maneuver capability with advanced digital flight control concepts results in significant improvements in weapon delivery accuracy and increased survivability. This aircraft entered flight test in July of last year, marking the first flight of an aircraft with a tri-plex digital flight control system and with no mechanical back-up.

The defense advanced research projects agency X-29 advanced technolgy demonstrator aircraft program is well underway, with fabrication scheduled to be completed in June of this year. The X-29 will demonstrate a number of advanced aircraft technology concepts, most notable among them is the forward swept wing. The X-29 configuration will feature improved low speed handling qualities, spin resistance, canard aerodynamics and relaxed static stability. First flight is planned for mid-1984. Between fall-out and first flight, extensive structural ground testing will be completed, all systems and subsystems will be installed and checked for operation and the flight control system hardward and software will be validated for flight.

Looking toward the future, there is growing concern regarding the survivability and sustainability of our land based tactical aircraft in light of significant increases in threat capability. The Soviets have substantially increased the range and payload of their forward based aviation assets, thereby placing our tactical airfields in jeopardy. The Air Force is seriously considering the requirement for short take-off and landing or STOL capability in the next generation fighter. In order to insure that full-scale development of this aircraft can proceed with acceptable risk in the 1987 time frame, we will initiate a STOL technology demonstrator program this year. This program will investigate several concepts to reduce take-off and landing distances, including thrust vectoring and reversing nozzles, integrated propulsion and flight control, advanced high lift devices and soft/rough field landing gear.

Our interest in advance rotor craft concepts continues to be very strong, with the current focus on the application of the tilt rotor technology to the joint services vertical lift aircraft identified as the JVX. The JVX program is oriented toward developing a new aircraft to perform a variety of missions in all three services including Marine Corps assault and search and rescue for the Navy; search and rescue and special operations for the Air Force; and, special electronic mission aircraft for the Army. We are confident that we can build a single aircraft to address these diverse requirements, because of the knowledge and experience we have gained in the joint NASA/Army XV-15 tilt rotor research aircraft program. Our efforts during the past year were devoted to a variety of operational type tests, including ship board trials with the Navy, which served to eliminate many of the concerns regarding the ship compatibility of tilt rotor concept through the application of advanced materials and flight control technology.

In January of this year, a memorandum of agreement was signed by NASA and DARPA to develop the technology base for the X-wing/rotor concept. The X-wing is a stopped rotor V/STOL aircraft which builds on the circulation control technology base established by the Navy over the past several years. The X-wing will be tested on the rotor systems research aircraft (RSRA). Additional objectives of the program are to generate engineering development design data critical to any future system development, and to acquire flight test data on the X-wing/rotor system in the compound helicopter and stopped rotor flight modes. Sikorsky will fabricate the text X-wing/rotor to be fitted on the RSRA, with first flight planned for the latter half of 1985.

In a related and important area, the Army is pursuing the development of the advanced digitial optical control system (ADOCS). The objective of this program is to demonstrate the feasibility of control of the helicopter solely by optical signal paths with no degradation in performance compared to a conventional dual mechanical flight control system. ADOCS will not only increase survivability through reduced susceptibility to electromagnetic interference, but will also provide improved handling qualities to reduce pilot workload and improve safety, particularly in the nap-of-the-earth environment. ADOCS will be demonstrated on a modified UH-60 Blackhawk helicopter with first flight planned for early 1985.

We continue to make significant progress in improving propulsion system performance while striving to reduce development risk and costs, maintenance costs, and acquisition costs for a broad spectrum of aircraft applications. Last year we reported on a large fighter engine technology demonstrator with the potential for a 15-percent increase in thrust to weight ratio, a 15-percent reduction in fuel consumption and a 24-percent reduction in the number of parts as compared to the F100 engine. Recently, an extensive cyclic durability test series has been initiated on this variable-bypass configuration both to verify life and to improve our understanding of the tradeoffs between durability and performance. Within the past year, we have also demonstrated similar performance improvements in the core of another configuration. Both of these efforts are ensuring technology readiness for transition to the joint fighter engine for the next-generation tactical fighter aircraft.

In the area of exhaust nozzles, we have recently tested carbon/carbon exhaust-nozzle liners for over 300 hours in an F100 engine, including four hours at maximum afterburning. Further, in conjunction with a contractor independent research and development program, we have demonstrated a laboratory model of a two-dimensional, thrust vectoring and reversing nozzle on an F100 engine with no adverse effects on engine operation. Studies have shown that thrust vectoring and reversing provides substantial decreases in take-off and landing distances for fighter aircraft. We have planned programs to utilize carbon/carbon materials to demonstrate a flight-weight two-dimensional nozzle and to demonstrate thrust vectoring and reversing on a fighter aircraft configuration.

We have also initiated the modern technology demonstrator engine program to demonstrate in a 5,000–6,000 HP class engine configuration a 20 to 30 percent reduction in specific fuel consumption compared to existing engines in this class (T55, T56, T64). We plan to transition this technology demonstrator to full-scale engineering development in fiscal year 1986 in support of the JVX program.

Last year we reported that programs have been initiated to examine the utility and effectiveness of metal-matrix composite materials for aircraft. The results of these early investigations revealed the vast military application potential for both filamentary and particulate reinforced metals such as aluminum, magnesium and titanium. Our interest in metal-matrix composites stems from the fact that while the structural performance characteristics are similar to those of non-metallic composites, they can be fabricated with existing metal-working tools and machinery and therefore will not require large capital investment in new production facilities. To capitalize on these potential military applications and the obvious production advantages, several major demonstration projects have been initiated. Under an Air Force contract, Lockheed Georgia Company is designing and will fabricate and test a C–5 size aircraft wing box subcomponent of metal-matrix composite. This component will be 25 feet long and will be designed to withstand loadings in the vicinity of the outboard wing pylon.

Based on the successful exploratory development program in metal-matrix composite reinforced helicopter transmissions which led to appreciable reductions in the sound and vibration intensity, the Army has contracted with Boeing vertol to design, fabricate and test several full-scale integrally reinforced metal-matrix composite gear box assemblies for the CH–47 forward transmission housing. In addition, the Army is pursuing the development of metal-matrix composite landing gear skids for the UH–1H helicopter. Success in this program could lead to appreciable weight reductions in these components.

We are continuing to exploit the advantage of organic composite materials for aircraft applications. The Army's advanced composite airframe program ACAP is entering the fabrication phase this year. In the ACAP program we will develop and flight test an all composite helicopter fuselage. The goal of the program is to demonstrate a 17-percent reduction in cost and a 22-percent reduction in weight compared with a baseline design of conventional metal construction. Two different design approaches are currently being pursued under contract by Bell helicopter and Sikorsky, with both aircraft scheduled to begin flight tests in mid-1984.

An important aspect of our national effort to develop aeronautics technology is the availability of proper research facilities. This was recognized by the 94th Congres when they established the national aeronautics research faciities program. This program provided for the Langley National Transonic Facility; modifications to the Ames 40 x 80 foot wind tunnel, including the construction of the 80 x 120 foot test section; and, the aeropropulsion test facility at the Arnold Engineering Development Center. These facilities are now becoming operational and we are confident that they will contribute significantly to the U.S. ability to remain preeminent in aeronautics technology. We note, however, the unfortunate accident in the Ames 40 x 80 foot tunnel, which will require 21 to 24 months to repair. The availability of this facility is critical to the development of the JVX aircraft. Under the present repair schedule, JVX development can proceed without delay. However, any extention of the repair time will cause a commensurate delay in the development of JVX. We will work closely with NASA to assist in whatever way we can to regain the test capability of the 40 x 80 foot tunnel as soon as practical.

I would like to conclude my discussion of aeronautics activities by noting that over the past year we participated extensively with the President's science advisor, Dr. Keyworth, in a study to develop an aeronautics research and technology policy for the 1980's and 1990's. That study, which was completed in November of last year, stressed the importance of superior aeronautical capability to national defense, and reaffired the Government's responsibility to maintain and advance that capability. The study further concluded that the present institutional framework to discharge the Government responsibility was the only approach that will ensure that: DOD needs will be met; aeronautics technology will be freely interchanged within the industrial community; technology to meet long term civil and military needs is developed; and, productivity of aeronautics research and technology is maximized. We fully support these conclusions and will work closely with NASA to insure that this policy is implemented to the maximum extent. I believe that through support of this policy, we will be assured of developing superior military aifcraft, and that the U.S. will maintain a viable and productive civil aircraft industry which will be a long term benefit to the Nation as well as DOD.

This concludes my formal statement. Mr. Chairman, I will be pleased to accept any questions the committee may have.

Senator GORTON. Thank you very much.

Let me start with this. Your written testimony indicates an all time high of Soviet space launches last year. What portion of these do you estimate are in support of military missions in the sense that we migh distinguish DOD from NASA space missions here?

Dr. DELAUER. I tend to be very, I would say, almost paranoid on this subject. I don't think they do any space launches that aren't military connected in my own view.

Senator GORTON. They are not engaged in anything like the scientific research in which we——

Dr. DELAUER. I think they do, but I don't think that is their primary aim in life. They don't have a document like you read in the beginning which said that the focus should be in one place, but on the other hand, where the military is necessary—they don't make that distinction.

Do you have anything to add to that, Bob?

Dr. COOPER. I think that classically the Soviets have done about 80 percent of their flights primarily related to military operations and about 20 percent have been devoted to other kinds of activities that you might place in commercial or scientific bins if you had to put the launches in bins.

But interestingly enough from the intelligence estimates this year, this is the first year in my recollection there were no identifiable scientific satellites, that is where it was specific. It is the first time in my recollection, and I have followed this activity for probably 10 years or so, that this has occurred. So I suspect that the tempo of their military activity in space is increasing and the tempo of their scientific activity is somehow diminishing over the past few years.

Senator GORTON. Do you have any explanation or rationale for that change?

Dr. COOPER. No, I don't, although we know that the Soviets have a wide variety of experimental projects ongoing to increase the capability of their forces. It may just be that the total resource that they have available to work on space flight activity is now at least temporarily devoted to trying to bring these military related space missions to fruition.

Senator GORTON. Aerospace Daily recently reported that the Soviet Union's version of NASA's space shuttle Orbiter has been seen for the first time near Moscow. Your testimony indicates that the small version of this Orbiter could be launched [deleted]. Has this emerging capability been anticipated by DOD in this time context, and does it alter in any way your plans for using our space shuttle?

Dr. DeLauer. I think if you examine the intelligence estimates over the last few years, we knew they were working on something like this.

As you know, we are making every effort to provide to certain members of the committee access to some further evidence of their effort, and I think that Mr. Beggs might have that available to him. We can't do it even at this classification at the present time. [Deleted.]

Senator Gorton. You spoke in your testimony of a unique element of the Soviet effort being its manned space program. By the same token Dr. Keyworth has downplayed the necessity of man in space and suggest that the Soviets are forced to this course by technological limitations. Do you want to comment on that?

Dr. DeLauer. I am not going to get into an argument with the White House. On the other hand, we are supporting NASA's current space station activities. There could be some very useful capability in the future from DOD's standpoint—particularly the building blocks that are necessary to do it.

I think Bob has an additional comment on that.

Dr. Cooper. I think that there is a technical asymmetry between the Soviet Union'sd capability and ours which may make it more necessary for them to rely on man in space, and that is that they are definitely not as advanced as we are in automation technology generally. Automation technology is based on micorelectronic circuits and computer science, areas where the United States has been classically very strong. So we can rely on automation to do many of the complex tasks that must be done in space, whereas the Soviets in order to accomplish similar kinds of missions may have to rely on a human being there making judgments and controlling systems in order to accomplish similar missions.

Senator Gorton. Dr. DeLauer, following up on that, or Dr. Cooper either, you did speak of the fact that the Soviets recently set a new record for time in space on the part of an individual.

I understand that the physical consequences to those individuals was rather adverse. What comments do you have on that? Have we learned anything from the long time in space on the part of the Soviet astronauts, in addition to whatever physical consequences there may be when they return to earth? Does it have any apparent impact on their ability to carry out these tasks some of which apparently we automate?

Dr. DeLauer. I will let my whiz answer this one.

Dr. Cooper. Yes, it is true that both very short times in space and very long times in space seem to be deleterious to functioning in complex tasks in space. In the space shuttle program we have experienced some problems——

Dr. DeLauer. Short term.

Dr. Cooper [continuing]. With astronauts becoming ill for a few hours initially while they are in space and the Soviets have experienced similar circumstances.

Then there are debilitating long-term effects from being in space that have to do with certain upsets in the body chemistry of people who are subjected to zero gravity for long periods of time.

Now the Soviets have mounted a major effort to study the effects of space flight on human beings, and we have benefited from that program because we do have a cooperative exchange of information program with the Soviets in this general area. Although we haven't had as many man-hours in space as the Soviets have now, we have had considerable long duration exposure in space experience and have gained some insights there. But clearly there are medical problems to be overcome to keep astronauts in zero gravity for extended periods of time. We do need to understand more about that, particularly if we are to rely on military man in space for any substantial important missions in the most distant future that require long durations in space. The Soviets have stated a goal for year long invasions.

Senator GORTON. Well, we are still simply on the learning edge I take it in this respect. You haven't developed a rule that you wouldn't want someone up more than *x* number of days or under certain circumstances or the like?

Dr. COOPER. No, there is no rule like that, as you say, but there is a certain body of understanding about the effects and some things that can be done to counteract those effects. I think that is what we need to do, is to better understand the physics and the chemistry of the effects to better understand what actions can be taken to either delay or diminish the onset of those effects.

Senator GORTON. Do you all agree with NASA that a space station should be the next major American space initiative?

Dr. DELAUER. Yes, I think we agree with them that that is the next civil effort that ought to be done. I think there may be a difference in time scale between us, but that generally is a consequence of having to pony up the costs. So we are just very cautious about being too bullish on space stations until we really know what it looks like as a program and that is NASA's responsibility to lay it out but we have supported their planning. I think the Secretary has written Jim Beggs a letter saying look, we support your activity.

Senator GORTON. Is it likely that the defense requirements will be so different from NASA's civilian requirements in that respect that DOD will require a separate program and schedule?

Dr. DELAUER. I don't believe so in the beginning. I think the earliest efforts will be on finding programmatic ways to establish a space station more than its utilization at the outset.

Senator GORTON. Your written testimony says, and I quote, "To constrain ourselves prematurely to a four-orbiter fleet would erode confidence in the space transportation system as a dependable space transportation system."

Dr. Keyworth seems to feel that a four-orbiter fleet is more than adequate for any foreseeable national needs. Can you comment on the difference between you?

Dr. DELAUER. I think there is a difference between whether the glass is half empty or half full, and somebody says look, the four orbiter fleet can match what we have to do and therefore that is adequate. We tend to be a little bit more cautious from a military standpoint. If we are going to count on the shuttle for activities, we want to be sure that we have got enough capability available to say look, it is a reliable launching system. Therefore an additional vehicle looks to us as a good insurance policy.

Senator **Gorton**. What do you understand the President's position to be on this issue?

Dr. **DeLauer**. Well, right now they haven't approved the fifth one. So I guess I stand on the record, so to speak. I think it has to do with how we do in the future and see what happens.

Senator **Gorton**. Your testimony indicates that our spares posture for the orbiter fleet is tenuous and inadequate. Does that mean that the $100 million proposed for spares in the fiscal year 1984 NASA budget is too small?

Dr. **DeLauer**. Yes, I think it is too small if we start having some problems like we are having now.

Senator **Gorton**. Can you give me any insight into what you think a more adequate level or appropriate level would be?

Dr. **DeLauer**. I would hesitate to give you that number right now. We can get it for you. Why don't we try to get it for you.

Have you got it?

Dr. **Cooper**. No. I think it is better that we should look at the problem and give you a judgment for the record.

Senator **Gorton**. Is there any inclination on the part of DOD to fund part of the spares inventory if NASA can't do it?

Dr. **DeLauer**. We don't volunteer anything right now, but we are always reasonable men as far as working with NASA.

[The following information was subsequently received for the record:]

I was describing our *current* spares posture as "tenuous to inadequate" as evidenced by the current unavailability of serviceable Shuttle main engines. This situation is the result of insufficient resources previously applied to spares, and the impact of funds requested in the fiscal year 1984 budget will not be felt for several years due to lead times.

With respect to the appropriate level of funding for Orbiter spares, we defer this determination to NASA who has the responsibility for this element of the Shuttle program. We are encouraged by recent increased attention to this issue by NASA management, and have made available to them trained DoD Logisticians to assist in this difficult task.

From our perspective, the most important consideration in determining spares funding levels is achievement of the capability to responsively support user requirements. A corollary requirement is to maintain spares production capacity to enable efficient production of additional Orbiters if circumstances warrant.

Funding of Orbiter spares is a NASA responsibility under the NASA-DoD agreement for use of shuttle and is a reimbursable cost element. We believe that the recently renegotiated price per flight for use by the DoD reflects the cost projection for additional spares procurement by NASA. Under this agreement the DoD cost per flight has increased significantly from $12.2 million to $29.8 million in the post 1985 period (all costs in fiscal year 1975 dollars). DoD does fund for all spares associated with DoD operated elements of the system, such as Vandenberg AFB Shuttle facilities.

Senator **Gorton**. What are the prospects that DOD might require that an orbiter be reserved for its missions only?

Dr. **DeLauer**. Well, you know that is hard to say because right now we do have some spare booster capability which kind of gives you a little warm feeling. But once those are consumed, why I think we have to re-examine the whole question of emergency needs. We are looking at a broad based capability of how you would really handle an extended requirement for emergency replacement of satellites.

Dr. **Cooper**. Specifically though, sir, we have no particular technical requirement that would require a separate orbiter just for some specific technical military purpose. We can use the general capability that is in the STS system now for all of our future projected missions.

Senator **Gorton**. Do you see a point at which DOD payload rates will exceed the launch capacity of the shuttle?

Dr. **DeLauer**. Not in the foreseeable future.

Dr. **Cooper**. Certainly not in the foreseeable future.

Dr. **DeLauer**. Hell, no. We have to be sure that it fits.

Dr. **Cooper**. You see, there are two aspects to that problem, Mr. Chairman. One is the weight-lifting capability and the other is the volumetric capability of the shuttle. We see no missions in the near term that would exceed the weight-lifting capability. In the more distant term if we do develop a need for high-powered lasers in space as weapons, our projections are that systems weights are likely to exceed the weight-lifting capability of a single shuttle flight.

As far as volumetric capacity goes, the shuttle now is marginally adequate for all projected missions to carry the volume of both the upper stage and the spacecraft into orbit. It is likely that there will be some missions in the future where we will have to go to great pains to shoehorn those missions volumetrically into the shuttle payload volume.

Senator **Gorton**. Given this set of marginal or inadequate capabilities, are you considering an alternative launch vehicle?

Dr. **DeLauer**. No.

Dr. **Cooper**. No. The alternative to the limitation is to assemble pieces of spacecraft in space. Both NASA and DOD are looking in a conceptual way and to a certain extent in a technical development program at ways of doing space assembly.

Senator **Gorton**. Has consideration been given by DOD to bumping STS-9 to assure the scheduled launch of STS-10?

Dr. **DeLauer**. I don't think so. That hasn't come to my attention, Mr. Chairman. Now whether they are doing some planning in the organization, particularly with the user, we haven't seen it surface.

Dr. **Cooper**. Currently the schedule for STS-10 is in November of this year. That flight has been scheduled for a number of years to occur in November, and we still have a need to have that flight occur in November. We are hopeful that the difficulties that the shuttle is having now will be cleared up and that the missions preceding flight 10 will be launched with dispatch so that we can actually have that mission occur on time in November, without disrupting the rest of the schedule.

Now how NASA intends to handle that problem and how successful they will be at it is an operational matter for NASA.

Senator **Gorton**. What are the cost penalties that we are going to face if we keep on deferring a decision on the fifth orbiter and eventually decide to go ahead with it for 1 year, 2 or 3 years, whatever?

Dr. DeLauer. Well, I would think off the top you are going to get stuck with inflation. While it has been reduced at this point in time, it is not zero. So we will have that problem.

Senator Gorton. You will have more than that though, won't you?

Dr. DeLauer. It probably will. It depends on where the work force sits at the time you make the decision. If you are going to put a gap in the shuttle work force, it is going to cost you more money. That is probably the biggest impact that we might be facing. So it is up to NASA to really look at how the layout is, particularly at the suppliers and see whether or not we are going to be paying for both a drawdown and then a buildup in people. That is the biggest cost facing us.

Senator Gorton. Is private sector funding for the fifth orbiter an acceptable alternative as far as DOD is concerned?

Dr. DeLauer. Again, just like we are talking about having adequate controls on other civilian controlled space assets, we would try to insure that we would have adequate control of an orbiter that was privately financed.

Senator Gorton. But the concept itself doesn't bother you?

Dr. DeLauer. No.

Senator Gorton. Does the pricing schedule in the memorandum of agreement for shuttle launch services by NASA for DOD represent the full cost of those services?

Dr. DeLauer. I think they are the full cost if you take into account the relevant effort that we have within the manpower. I think there is a difference in cost at the Cape than, say, there would be at Vandenberg because of the different employment of people.

Senator Gorton. Expan on that a little. What kind of difference?

Dr. DeLauer. Well, I think you have more support personnel that are military in one, and their costs are covered in the military budget and therefore you wouldn't have to handle that particular aspect of it, than if you go to a different place. I think it will be different a little bit, too, when the time comes as to whether or not we use all of the Johnson capability or we start using the CSOC capability for some of the control.

But I think the concept of the pricing is pretty much agreed to and I think it is fair.

Senator Gorton. How do the charges of DOD differ from those which NASA assesses to commercial users?

Dr. DeLauer. I think it is probably the utilization of the people more than anything else, isn't it, Bob?

Dr. Cooper. It is just exactly the same, except for the charges for people.

Dr. DeLauer. You know, the credit for providing additional labor and things like that.

Senator Gorton. What does DOD see as the main advantages to be gained from your shuttle processing contract which is expected to be awarded by NASA late this year?

Dr. Cooper. Well, we think that contract will be a good contract. The major benefit to both NASA and DOD will be the use of a common contractor on both the east and the west coast for services there. I think that will be a major benefit and there will be substantial cost reduction implications to that.

Senator GORTON. Do you see the contractor having any responsibility for increasing commercialization of shuttle services?

Dr. COOPER. I don't see that.

Senator GORTON. And does increased private managerial responsibility for shuttle processing introduce any new security problems for DOD?

Dr. COOPER. No, sir.

Dr. DELAUER. Not that I can see. We handle most of the security problems much more complicated than this with a good government contractor team effort.

Senator GORTON. I do have questions on other subjects, though that completes it on the shuttle. Senator Trible has sat here patiently for an extended period of time.

Senator TRIBLE. I thought I was experiencing my first Senate filibuster.

Senator GORTON. I will defer to you for a while.

Senator TRIBLE. I appreciate that. I don't have many questions and I was about to depart.

Dr. DELAUER. Was he talking about us or about the Chair?

Senator GORTON. I think he was talking about the chairman.

Senator TRIBLE. I couldn't possibly say that about my Chairman. If the shoe fits, let anyone wear it.

Dr. DELAUER. Well, you know, you get coached, Senator, about how to answer questions when you come before committees like this, and when things get to you, boy, you lengthen them out.

Senator TRIBLE. I have enjoyed and benefited from your colloquy with the Chairman.

Let me just pursue a different line of questioning, if I may.

I have been sensitized to the importance of the space program by the parochial interest of my congressional district, the congressional district that I have represented for the past 6 years where NASA activities are incredibly important.

It is my view, because of those parochial interests and also my perception of national requirements, that the first nation to successfully project and sustain a presence in space will not only prosper, but will dominate the course of human events. My job is to look into the next century as a U.S. Senator, and I hope to be here in the next century as well.

To that end I am particularly interested in the potential military uses of space. The production and employment of strategic nuclear weapons of an offensive nature will be severely limited in the days ahead by many factors, including national consensus.

I have been a staunch supporter of the development of a modern land-based intercontinental ballistic missile. It is my view, however, that the consensus for that may well have disappeared over the 2 years. I think this administration has moved forward too slowly. I think the fragile consensus that existed in the waning days of the Carter administration no longer exist. I think it is quite frankly quite likely that we will have to forego the modernization of that part of the Triad and put our strategic forces to sea. That is an aside. That is not really a central part of my question, but I think it states the basis for my question.

Because of these and other problems, I think it is incredibly important that we move ahead in space. This may or may not be the proper forum for you to answer these questions. As a member of the Armed Services Committee in the House I was directly privy to some information and I suspect that that information may be available in this forum. I don't know.

But I want to know specifically what we are doing in terms of the antisatellites, lasers, particle beam weapons and those kinds of things.

Dr. **DeLaurer**. We will split the answer up, Senator, but let me not miss an opportunity to respond.

Senator **Trible**. See, I am already affected by the Senatorial urge to talk at length. I carried on and I apologize for that.

Dr. **DeLauer**. But you had such good practice with the 5-minute rule that I thought you would carry that over.

Senator **Trible**. I don't think I have exceeded my time as yet.

Dr. **DeLauer**. Not yet.

Since you opened the questioning to the land-based missile system, let me take an opportunity to respond to that.

Senator **Trible**. Please.

Dr. **DeLauer**. There is no question that we have got a tough road ahead of us, depending on how the Presidential Commission comes out. People refer, just as you have, to losing the consensus. It is very convenient to talk about a consensus, assuming that people all had the same understanding of what the subject was and therefore you had a consensus on a particular subject.

I think the understanding of the need for a strategic deterrent is less now than it was when we first fielded it. I think the way people have been exposing the issues in contrived nuclear wars on TV, on exposing predictions of casualty aspects of a protracted or even an unprotracted nuclear exchange. all these things while alluding to maybe a better understanding if, put in context, have led to one where all of a sudden the fact that what you are trying to do is deter a war and provide a deterrence has been misplaced by the fact that the existence of the weapons implies utilization. I think therein lies some of our problem.

Now I think it is appropriate for this committee, because it is an aspect of this Committee on Science and Technology, to recognize what we might be faced with if indeed we decided, or somebody decided, either the administration or the Congress or the American public, that all we had to have was a triad, or in your particular scenario you had most of it at sea. I don't know whether by accident or on purpose, but you failed to even mention the fact that we had to modernize the bomber force.

Senator **Trible**. I am for doing all of the above, Dr. DeLauer, as you ought to know and probably do know by my record in the Congress.

Dr. **DeLauer**. Yes. If there is one thing about the triad, it really complicates the life of anybody that wants to do anything against it, particularly in science and technology.

If you take a look at a survivable land-based missile system, one that has a reasonable level of survivability, all the direction, all the effort and all the resources necessary to counter that has to do with things that led to penetration, to preciseness in operations, in assessment afterward to be sure you know what you have. Those are the whole kinds of technology, the high accuracy, the whole question of the technology base that represents missile technology at the terminal end.

Then you take a look at the bomber leg, a modern bomber leg with its penetration capability, and the assets of the defender has to be one of microwave technology, tremendous installation of fixed facilities, netting them in a very complicated way, handing large amounts of data in a way that is very expensive and extensive. And, particularly when you start talking about low observable capability, it even makes it more complicated.

Then you take a look at the sea-based portion of such a system and the technology won't be any different there. It is signal processing, and it is signal processing of the toughest kind. To counter that sort of thing is a tremendous investment.

So when you look at the three legs of a triad, and not just the fact that they indeed provide capability of different kinds, they also present a problem to the adversary. If we essentially reduce our strategic deterrent, remember we don't want this thing to be used, so it has to be credible, and that means it has to be survivable.

In one particular phase I can predict, and I may not be around to see it, but you will because you are going to live into the next century. You just told me that.

Senator **TRIBLE**. I hope the good Lord and the people of Virginia are willing to give me that opportunity.

Dr. **DELAUER**. Even under those sorts of things, they have caught up with me.

Senator **TRIBLE**. I have that potential ability and I hope with God's help to realize it.

Dr. **DELAUER**. They will solve that problem. They will solve that particular problem in one way or another. So now that has taken care of the first part of your question.

Now when we talk about the laser program and what we are going to do, to answer your second question, I will turn that over to Bob Cooper. It is in his area of jurisdiction and he manages that operation.

Senator **TRIBLE**. Let me just say one thing, and then if you will give me your answer, and then I will yield very quickly back to my chairman.

I share your view that we need to strengthen and modernize all three parts of the triad. It is not the Trinity, but I do believe it has served us well and that we ought to continue to put our strategic eggs in three baskets and not two.

Having said that, there are some very real political obstacles and for those or for other good reasons I think the defensive aspects of the strategic equation will assume greater importance, and therefore I think we need to focus our resources and energy on space as well as on these other initiatives. It seems to me they will be increasingly important in the days ahead, and I know you don't argue with that.

Dr. **DELAUER**. Not a bit.

Senator **TRIBLE**. So I am particularly interested in what you may be doing or perhaps what we ought to be doing but we are not.

Dr. Cooper. All of the DOD programs that deal with strategic defense in space are in exploratory development phases only. Exploratory development means that we have concepts that we are exploring that may work in the future, but they have significant technology questions associated with them.

Programs that fall into this category are the space laser program, the neutral particle beam weapon program, the electromagnetic gun program, and the impacter technology program. These are four programs, all of which are in ARPA, and it is interesting that ARPA is an organization that pursues high-risk, potentially high-payoff research for the most distant future. All four of these key potential space weapon programs are in ARPA, I think, for that reason.

Let me see if I can characterize for you where these programs stand. In the space laser area we have expended over the past several years a sizeable sum of money preparing to do major fasibility demonstration experiments in the three broad technology areas at issue.

One in the laser itself. Without a laser you can't have a space laser weapons system.

The second is in the large, high-powered optical system that would be required to be combined with the laser in order to be able to project energy thousands of kilometers.

The third is in an experimental program to be able to acquire, to track and to point at targets at these great ranges.

Over the past year we have come under contract for all three of these major elements. In the one, the large optics, we have two major contracts and we intend to narrow down to one contract in the very near future. As a matter of fact, that selection will be made within the next few months.

The laser development called ALPHA is an ongoing program and the program for pointing and tracking, called Talon Gold, is an ongoing program under contract now.

We expect that those three experiments will mature in the 1987–88 time period and tell us whether the key issues in each one of those areas can be overcome in an engineering sense, and that is exploratory activity.

The second program that we have ongoing is being carried out at the Los Alamos Scientific Laboratory and is an experiment to produce a high-energy neutral particle beam—neutral because particle beams in space, if they were charged, would be deflected by the magnetic filed of the Earth. So in order to be effective as a long-distance weapon to keep from having to shoot through a strange trajectory, to be able to shoot line of sight with such a weapon, the beams have to be neutral.

In that activity we have built an accelerator, have tested the neutralization of the beam over the past year, and we are testing the accelerator now at increasing energy levels hoping that by the end of the current fiscal year we will have tested that accelerator at its [deleted]. So that experiment is ongoing.

Two other programs, the electromagnetic gun program and the impacter technology program, are still at very early phases of their definition.

The impacter is a technique [deleted].

[Deleted.]

The electromagnetic gun program is one where we are still doing experimental work associated with accelerating projectiles to hypervelocity speed, hyper-velocities on the order of [deleted] per second. These are velocities that are comparable to the velocity needed to place objects in orbit, and these launchers have wide potential applications in military missions, among which may be launching aircraft from the decks of carriers in place of the current steam-launched catapults that we have. They can also be used as cannon to launch high-velocity projectiles for antiarmor missions and things of that sort. But they also can be used to launch projectiles in space to great ranges. If you can get projectiles up to velocities of the order [deleted] a second, they are comparable to the orbital velocities of objects in space [deleted] and essentially we are exploring that potential for this technology.

Aside from that we have no other technologies that are meant for space deployment that might result in weaponry in space.

Senator **Trible**. Let me ask one follow-up question, if I may, Mr. Chairman.

Tell me, if you will, in your professional judgment, are we providing an adequate level of funding for those programs given their preliminary nature, or should more money be dedicated to those purposes?

Dr. **Cooper**. It is my position that each one of those programs is adequately funded. Now for each one of them, there is uncertainty with respect to how much funding should be applied, as there is in all research projects. There is this delicate balance between an idea limited program and a dollar limited program, and it is a matter of professional judgment as to what the right expenditure level is.

I believe that we have the space laser program fully funded in the space laser plan that was submitted by the Secretary to the Congress last year. We have found ways within the current 5-year defense plan to fully fund that space laser activity and it is on track and I think we can meet our goals there.

In the case of a neutral particle beam, we are fully funded through this year. We have options for next year that depend particularly on the success of our specific program this year.

In both the impacter and the electromagnetic gun program, those are in very early stages and I believe that we are applying dollars probably more rapidly than the ideas can flow right now. So I think we are in pretty good shape in all of those areas, but again it is a matter of judgment. I am sure we are right within 5 or 10 percent in each of those areas.

Senator **Trible**. Good. Well, I thank you very much.

And I thank you, Mr. Chairman, for your indulgence.

Senator **Gorton**. Your testimony says that a decision regarding Titan production will be made if STS–6 is successful. What would constitute successful for purposes of this decision.

Dr. **DeLauer**. Well, that would be if we would get it in orbit. We would put the payload in orbit and we would not have a problem. I think that is more the way we are trying to characterize a successful thing, that we would get the job done.

Senator **Gorton**. Is there any concern that abandoning expendable launch vehicles in favor of the space shuttle would leave the defense space program vulnerable to the loss of an orbiter or critical spare parts?

Dr. DELAUER. I think that there is some concern.

Senator GORTON. This is in the area to which you just testified to Senator Trible that we are better off having more than one way of doing things?

Dr. DELAUER. That is right, and, as you know, we are looking at what would be alternatives to the situation. But until we have more experience, we cannot really count on the STS, which I don't quite honestly believe we can at this point. I mean we have demonstrated the system and there is no question it can do the job, but now it is a question of getting it on a schedule that operationally you can count on, and I think we can do that. So we are counting on STS to do the job for us, but that doesn't mean from a continuous planning standpoint you don't look at alternative ways.

For instance, to give you an example, you know we are talking about taking the Titan II's out and deactivating them. We took a good look to see whether or not we could utilize them for space boosters. It doesn't look like we really can without added cost, but we will save all the fuel. The fuel will be stored. So considering a major cost element of implementing essentially a Titan III capability again, we will have all the fuel and that is a lot of fuel. It is storable and all we do now is just pay storage costs. So that is the kind of contingency we continue to look at.

We have also looked at applications of the MX as an emergency space booster—what size payloads would be required if you had to have emergency communications and things like that—because all of this is tied in with how do you really handle a lot of the ancillary kinds of capability, [deleted] and all the things that you may need to reconstitute under certain conditions. We have to do that anyway, even if you counted on the STS. What happens if you lost a launch pad or lost both pads? You know, both of them happen to be in a very convenient place for somebody if they wanted to take some action against them. It doesn't take much to put them out of action. So I think you have essentially both a wartime contingency as well as essentially your peacetime activity and I think they take different magnitudes of concern and we are looking at all of them. But we are spending most all of out money really on pursuing the program as now laid out.

Senator GORTON. NOAA has proposed to deploy only one polar weather satellite rather than two as originally planned. Does DOD depend on the NOAA weather satellites as a backup for its own system?

Dr. DELAUER. Yes.

Senator GORTON. If so, has DOD assured that a one satellite civilian system provides the level of backup needed?

Dr. COOPER. Yes, we have looked at that and we believe that is adequate for our purposes. Mainly the NOAA weather satellites are used for backup in times when the DOD weather satellites are not available.

Now, unfortunately, in the past we have had some tough times with satellites not being available. So we have relied heavily for general weather information on the NOAA weather satellites.

We would hope that NOAA would keep a minimum of one satellite on orbit for backup purposes for defense in the foreseeable future.

Senator GORTON. Let's turn the question around. If the civilian polar satellite system were to stop functioning could the defense system provide backup information to the National Weather Service?

Dr. COOPER. No. There are key instruments on the commercial weather satellites which are not contained on the defense weather satellite that are required for certain kinds of weather prediction that is done only by NOAA for public, civil purposes.

Typical of military satellites, the defense meteorological satellite program has very specific uses as well as some general uses and by and large the complement of instruments on the two space craft is different and both are required.

Now that doesn't say anything about the synchronous meteorological satellites which are of some benefit to defense and which are crucial I believe to public, civil weather predictions. Those should be maintained. We hope that those will be maintained with the current complement.

Senator GORTON. The major new start in the NASA aeronautics program is the numerical aerodynamic simulator. Will the defense agencies be major users of this capability?

Dr. DELAUER. They intend to.

Senator GORTON. If so, are you satisfied that the NAS design is fully adequate for military aircraft design purposes?

Dr. DELAUER. Well, I think for what its use is now. We have high hopes for the future. We have a program just getting started under Bob's direction. The first funding will be in our submission in the 1985 POM. We are doing a little work now, what we call the *n*th generation, which is DOD's initiative to overcome the lack of enthusiasm on the part of the commercial side of the American industry to go after the fifth generation system. As a consequence, the *n*th generation supercomputer program has as one of its objectives in the military application a full three-dimensional computation for aircraft design, both Navier Stokes [deleted] as well as all the structural aspects of the thing. It has high hopes and this is one of our applications of what the *n*th generation supercomputer program might add to our capability.

Senator GORTON. We are generally familiar with the support by NASA of defense aeronautics programs. Do the DOD programs such as what you call modern technology demonstration engine program or metal matrix composite materials support NASA's propulsion and structures programs, and how do these DOD programs find their way into civilian aircraft applications?

Dr. DELAUER. Well, if you go back far enough, which I happen to be able to do, one of the original efforts on how to handle boron fibers came out of an Air Force planning exercise called Project Forecast in the early 1963–64 period which the Air Force Systems Command took on as a major plan. As a matter of fact, a lot of good concepts came out of it. The C–5 came out of it and a very large transport came out of it. They didn't plan to implement it like they did in the beginning, but the boron fibers came out of it.

Out of that came the whole question of composite technology and the military funded that and then it moved in a limited way into a lot of civilian economy, particularly in things that focused in the sporting goods end of it. But in the aeronautical end of it it showed up as elements of modern transports. The Boeing 757 and 767 have a lot of composite material in them. As a matter of fact, they are finally getting to where it is some composite primary structure. We used it as a secondary structure in the past.

[Deleted.]

You know I can predict that probably the next commercial airplane will have a [deleted] because you sell an airplane on cost per seat mile and that is going to make a hell of a difference, that plus the low specific fuel consumption engines which are now in existence. So we can make some improvements on that.

So between the two of them we have made commercial aviation. If we hadn't given away the CF-6 engine, we would still have had our hands on all of it, but that was something else. That is another subject for another time.

Senator GORTON. I am only about half way through the questions which I had prepared for you all. We, however, will have a series of rollcalls beginning at 11 o'clock. So I am going to submit the rest of my questions to you in writing and defer to Senator Heflin.

Senator HEFLIN. I will have to submit a major portion of my questions in writing, too, but let cover one or two areas.

What portion of the BMD budget in 1984 to 1988 is dedicated to space defense activities?

Dr. DELAUER. The BMD budget, Senator? If you take a combination of both what is in the Army BMD and what is in our ARPA program and put that together, I would say——

Dr. COOPER. I think we ought to go back and get those numbers for you in detail.

Dr. DELAUER. The laser program he talked about has some BMD aspects of it. As you know, they are looking at a homing vehicle which could be utilized in space. So we will get you the numbers on that.

[The following information was subsequently received for the record:]

Space defense, from boost phase until just prior to reentry, accounts for approximately 15 percent of the fiscal year 1984 BMD budget. This allocation is programed to increase to approximately 35 percent of the BMD budget by fiscal year 1988.

Senator HEFLIN. Why is SOFAS/FAST activity been reduced or terminated?

Dr. DELAUER. SOTAS?

Senator HEFLIN. No, SOFAS, sofas as some of them call it.

Dr. DELAUER. You have got me, Senator. You caught me short.

Senator HEFLIN. It is a forward acquisition sensor program.

Dr. DELAUER. The forward acquisition sensor program. That beats me. I will go back and find out why we terminated it, if we did. First, I have got to find out what it is.

[The following information was subsequently received for the record:]

The budget for the Forward Acquisition System (FAS) Technology Development Program was reduced in fiscal year 1983 to make funds available for the higher priority Endoatmospheric Nonnuclear Kill Technology Development Program. Survivable Optical Forward Acquisition Sensor (SOFAS), an application of FAS technology to the tactical warning/assessment, was never approved or funded. Since FAS was reduced, the potential for near-term development of SOFAS was eliminated. We continue to believe that other technology areas warrant a higher priority than SOFAS/FAS; however, we are continuing a low-level of activity in the development of the critical signal and data processing technologies for FAS and SOFAS applications.

Senator **Heflin**. Well, would you describe the potential development for the exo-atmospheric defense of ballistic missiles?

Dr. **DeLauer**. The exo-atmospheric program?

Senator **Heflin**. Yes.

Dr. **DeLauer**. I know what that is. We have got the program now configured toward looking at what the most suitable defense of the concept of land-based missile systems that now exists, which is the closely spaced basing. Thus, we are looking within the atmospheric point defense more than we are looking exo-atmospheric. We had the homing vehicle that I talked about, which is exo-atmospheric. It is a [deleted] homing system. We have had one test with that out in the Pacific and we are continuing. We have got another test coming up shortly. But that homing vehicle program is on its way. We have let the contract with L.T.V. Vought on the vehicle itself. That contract is out, it is being negotiated but it has not been awarded. So that is the sensor part of it.

The overall systems aspects of it have been, other than this experimental work, somewhat reduced as we try to refocus the BMD aspects on things that have to do with point defense, and that goes into nonnuclear capability. We are putting some more effort into nonnuclear things, the things that Bob talked about. The electromagnetic gun, for instance, is one that can contribute to that.

So the Army is restructuring the BMD program at the present time to focus more on things that Senator Trible said, you know, looking at the defense of the land-based missile systems.

Senator **Heflin**. What are the major technical issues to be resolved in the exoatmospheric defense, and provide a timetable for potential deployment? Maybe you had better put that in writing.

Dr. **DeLauer**. We will do that.

[The following information was subsequently received for the record:]

Exoatmospheric ballistic missile defense (BMD) could potentially provide high leverage, large payoff defense capability against ballistic missile attack. Intercepts in the exoatmosphere could be made with nonnuclear defense weapons, and could provide a large "foot print" of defended targets. The following specific efforts within the BMD program are/will be included in the exoatmospheric defense activity:

[Deleted].

[Deleted].

Senator **Heflin**. Let me ask on this antisatellite defense. I of course saw in this morning's paper that there will probably be a proposal for transfer of Government owenrship of satellites, some satellites to the private sector. If this is done, does this raise defense issues of those satellites, or are there military and space implications of those? Has the various ancillary issues relative to space and military been explored if there were to be a transfer relative to the satellites that are under consideration today?

Dr. **DeLauer**. Yes, sir. As I answered the chairman——

Senator Heflin. Has that already been asked?

Dr. **DeLauer**. No, not quite. I alluded to it. He asked particularly about the shuttle, wondering what the impact would be if you had private ownership of the shuttle which they are talking about for the extra one. I alluded to the fact at that time that we were concerned about proper safeguards and that falls right into this question you asked.

The paper article this morning had to do with the civil weather satellites. Our view is that with the proper safeguards, with access to data—you know really what we want to protect is the data stream—private ownership could work. So we would have to have an understanding in regard to its continuing availability and then access to the data stream. If we could be assured of those kinds of things, I think we wouldn't object.

Senator **Heflin**. I am told that the Landsat as well as weather satellites will be transferred to the private sector.

Dr. **DeLauer**. The Landsat?

Senator **Heflin**. Yes.

Dr. **DeLauer**. That is true. In the Landsat system again we use some data from it, and again we must be assured that we have that available. There is some very high technology in Landsat and we must protect that also.

Senator **Heflin**. Now from the DOD's standpoint what are the key issues to be decided in determining the feasibility of a manned space station for military activities? That may have to be more detailed in writing.

Dr. **DeLauer**. I think the first thing is what does the program entail and what is going to be the funding required because it is a resource allocation problem with us. I don't think there is a question in our view of the technical feasibility. It is the question of how fast and how much and then taking a look at how it fits into our other missions.

Do you have anything to add?

Dr. **Cooper**. I think the key issue here is the mission. That is, what is the military mission for a manned space platform. We have been working closely with NASA to try and determine what military potential this space platform might have and the participation by defense in such a program. The extent of that participation will really depend upon the outcome of our assessments of what military missions might be applicable there.

Senator **Heflin**. What are the major issues to be resolved in determining whether to concentrate on laser or particle beam capability as ASAT technology is developed and deployed?

Dr. **Cooper**. Well, both of those programs being ARPA programs and I am quite familiar with the issues there. I think the major issue is one of the vulnerability of the targets. The major differences between particle beams, that is delivering energy with particle beams, and delivering energy with light, photons, is the question of how the targets react to those two different kinds of energy.

The issue basically is what is the technology that incorporates the widest range of targets within a lethal vulnerability. I think the issue will be resolved over the next few years as we are able to exercise our neutral particle beam weapon program against laboratory targets and as we look at the lethality of laser weapons against typical targets that might be found in space or transiting through space. That is part of our program and it is one of the technical issues that we are trying to resolve within our exploratory development program.

Senator **Heflin**. How do the U.S. efforts in the ASAT technology compare with those in the Soviet Union in terms of both performance and schedule rather than just the numbers of the satellites that are dedicated toward that role?

Dr. **Cooper**. Well, there is one major difference, and that is that the Soviets have one and we don't. They have an operational antisatellite system which they test regularly [deleted] that they could use in times of hostility.

Now our program is still under development. [Deleted.]

Senator **Heflin**. One other question relative to laser technology development.

Is there any effort to coordinate the activities going on in the various branches of the service and the Department of Defense the energy in space to a little degree?

Dr. **DeLauer**. That one, Senator, I can answer with a resounding yes. If you haven't been aware of it, we have focused the whole coordination of the space-based laser program and the particle beam program all in an office that reports to Bob in research and engineering. We have got a Major General Lamberson in charge. He came out of the Air Force's laser activity. It is his job to essentially provide the focus and the management oversight on all the programs that are being done, no matter where, within the Department of Defense.

Senator **Heflin**. Are there duplications going on relative to this by various branches?

Dr. **DeLauer**. Well, not in any major way. You might find that some people are doing some basic materials work or things like that, but not as a program. The program is well managed and well planned and the duplication has been kept to a minimum.

Senator **Heflin**. That is all.

I will submit some questions in writing.

Senator **Gorton**. Thank you both very much for coming.

We will have additional written questions.

Dr. **Cooper**. Thank you, Mr. Chairman.

Dr. **DeLauer**. Thank you very much, Mr. Chairman and Senator.

[Whereupon, at 11:05 a.m., the subcommittee adjourned, subject to the call of the Chair.]

[The following information was subsequently received for the record:]

Questions of the Committee and the Answers Thereto

Question. What are the major issues to be resolved in determining whether to concentrate on a laser or particle beam capability as ASAT technology is developed and deployed? When will the DoD be in a position to make these decisions?

Answer. The DoD is pursuing a number of Directed Energy technology efforts that have ASAT potential.

Included are mid infrared and short (visible) wavelength lasers and neutral particle beam weapons. For ASAT applications of lasers we are looking at ground, airborne and space based weapons. One of the primary questions that must be resolved is non-technical and is related to the type of directed energy ASAT capability that is required to complement the USAF Miniature Vehicle (MV) effort. The major technical issues are related to our ability to demonstrate that we can build the directed energy systems with the performance capability dictated by the selected basing option.

The only concept for a particle beam ASAT weapon involves the use of a neutral particle beam from a space-based platform. This technology is substantially less mature than either the long wave or short wave laser technologies. We are presently pursuing a program to demonstrate the basic feasibility of generating a neutral particle beam with the necessary particle energy and beam current, and with sufficiently narrow beam spread to be useful as a space-based weapon. In addition, the technologies of space power source (including nuclear reactors) and power conditioning systems are being explored.

Both lasers and particle beams are likely to eventually find utility in a number of mission applications, tactical as well as strategic, terrestial as well as in space. A decision on laser versus particle beam technology for antisatellite application should not be made except when selecting a concept for validation in response to a formal operational need.

Question. GAO raised the issues of poor technical performance and affordability in critizing the F-15/ASAT program. What is the DoD's response to these charges?

Answer. We do not agree with the GAO on their technical assessment of the ASAT program, nor do we concur with their cost escalation to "tens of billions of dollars." We are in the process of formally responding to their report.

Question. How do the U.S. efforts in ASAT technology compare with those of the Soviet Union? In terms of both performance and schedule? The answer should reflect the latest U.S. intelligence estimate of Soviet capability—not the numbers of Soviet satellites dedicated to the ASAT role.

Answer. At the request of the Congress, we are in the process of preparing a report that addresses this very question. The report is in the final stages of editing and coordination, and will be submitted shortly.

Question. Why has it taken the DoD until the 1980s to provide funding levels necessary to initiate ASAT technology for potential deployment? The situation is similar to DoD's handling of BMD activity for the last 12 years, i.e., lack of adequate funding and policy guidance.

Answer. We have always considered this program to be a technology-limited development as opposed to a funds-limited development and, in concert with the Congress, have structured the effort to meet an IOC milestone in the most cost-effective manner. As for policy guidance, the latest version of the Defense Guidance contains very specific guidance on the development of an ASAT capability.

Question. What portion of the BMD budget in 1984–1988 is dedicated to space defense activities?

Answer. Space defense, from boost phase until just prior to reentry, accounts for approximately 15 percent of the fiscal year 1984 BMD budget. This allocation is programed to increase to approximately 35 percent of the BMD budget by fiscal year 1988.

Question. Why has SOFAS/FAS activity been reduced and/or terminated?

Answer. The budget for the Forward Acquisition System (FAS) Technology Development Program was reduced in fiscal year 1983 to make funds available for the higher priority Endoatmospheric Nonnuclear Kill Technology Development Program. Survivable Optical Forward Acquisition Sensor (SOFAS), an application of FAS technology to the tactical warning-assessment, was never approved or funded. Since FAS was reduced, the potential for near-term development of SOFAS was eliminated. We continue to believe that other technology areas warrant a higher priority than SOFAS/FAS; however, we are continuing a low-level of activity in the development of the critical signal and data processing technologies for FAS and SOFAS applications.

Question. From the DOD's standpoint, what are the key issues to be decided in determining the feasibility of a manned space station for military activities?

Answer. The focus is not the feasibility of a manned space station for military activities, because such an endeavor is clearly feasible. In our views the question is one of utility in a resource constrained environment. In that context, the key issues relate to whether a space station offers any unique benefits or the opportunity to perform military missions more effectively or efficiently than alternative means. We are also concerned about the prospective implications of a joint military-civil space station (particularly with international participation) on national security interests including classified operations and technology transfer. We are currently addressing these issues.

Question. Your written testimony says that "to constrain ourselves prematurely to a 4-orbiter fleet could erode confidence in the STS (Space Transportation System) as a dependable Space Transportation System.

The President's Science Advisor seems to feel that a 4-orbiter fleet is more than adequate for any foreseeable national needs. Do you agree?

You also strongly support the President's policy on this issue. What do you understand is the President's policy on 4 vs 5 orbiter fleet?

Answer. The following excerpt is from a policy directive signed by President Reagan: "The Senior Interagency Group (SIG) for Space, established to implement my National Space Policy, has examined the issue of whether Shuttle Orbiter production capability should continue beyond the four orbiters currently scheduled for delivery.

"After reviewing various options presented by the SIG (Space), I have decided that maintaining orbiter production capability is in the best interest of the nation. This objective will be achieved through the production of structural and component spares necessary to insure that the nation can operate the four orbiter fleet in a robust manner. These spares will provide the necessary assurance that Shuttle operations will continue in the face of minor problems, modifications or other periods of extended Orbiter outages.

"While this decision does not constitute approval for procurement of a fifth orbiter in fiscal year 1984, it does partially preserve this option for a future decision should optimistic estimates of demand materialize and other conditions dictate. It is my intent that the full potential of the Shuttle concept as originally envisioned is achieved and commercialization of space becomes a reality."

Because of uncertainties with respect to the ultimate need for additional Orbiters, as evidenced by the position you attribute to the President's Science Advisor, we believe that preserving the option for additional Orbiters at a reasonable near-term cost is the proper approach. The President's policy accomplishes this goal.

Question. How much of the Air Force's previous efforts in the 1960's on the Manned Orbiting Laboratory can be transferred to requirements in the year 2000 for the military potential for man in space?

Answer. Many of the same considerations still prevail, and the central issue still has to do with the identification of military missions whose performance can be enhanced sufficiently by the presence of man to justify the expenditures of resources for this purpose. It should be noted that the demise of the MOL program was attributed to the assessment that man was not an essential element for the classes of space missions under consideration at that time.

Question. Provide 1984–1988 costs for DoD space activities by major program element and line item.

Answer. The Department of Defense does not list "Space" as a major program, and extraction of space and space-related costs from the overall DoD program structure is a laborious procedure complicated by the fact that some space-related activity is included with non space-related activity within a single program element, and judgment must be applied to allocate these costs properly. We are in the process of accomplishing this task and will be pleased to respond when these data are available.

Question. In assessing the appropriate size of the orbiter fleet, how do you consider nongovernmental requirements? Or do you consider only the requirements of the government?

Answer. Consistent with the goals of our national space policy to develop the commercial potential of space, we recognize that responsive and economical access to space is a necessary ingredient. From our perspective, nongovernmental requirements represent a prospective demand for Shuttle services, and they are considered in that light. However, we recognize there are competing alternatives, both domestic and foreign, in expendable launch vehicles. Issues such as these contribute to the uncertainty with respect to the ultimate orbiter fleet size, and we believe that preserving options for additional orbiters is the proper course while we resolve these uncertainties and acquire operating experience with the Shuttle.

Question. Your testimony indicates that our spares posture for the orbiter fleet is "tenuous to inadequate." Do you mean that the $100 million proposed for spares in the fiscal year 1984 NASA budget is inadequate? What would be a more appropriate level? What are the most important considerations in determining an appropriate spares funding level? Would DoD fund part of the spares inventory if NASA funds are not available?

Answer. I was describing our current spares posture as "tenuous to inadequate" as evidenced by the current unavailablity of serviceable Shuttle main engines. This situation is the result of insufficient resources previously applied to spares, and the impact of funds requested in the fiscal year 1984 budget will not be felt for several years due to lead times.

With respect to the appropriate level of funding for Orbiter spares, we defer this determination to NASA who has the responsibility for this element of the Shuttle program. We are encouraged by recent increased attention to this issue by NASA management, and have made available to them trained DoD logisticians to assist in this difficult task.

From our perspective, the most important consideration in determining spares funding levels is achievement of the capability to responsively support user requirements. A corollary requirement is to maintain spares production capacity to enable efficient production of additional Orbiters if circumstances warrant.

Funding of Orbiter spares is a NASA responsibility under the NASA-DoD agreement for use of shuttle and is a reimbursable cost element. We believe that the recently renegotiated price per flight for use by the DoD reflects the cost projection for additional spares procurement by NASA. Under this agreement the DoD cost per flight has increased significantly from $12.2M to $29.8M in the post 1985 period (all costs in fiscal year 1975 dollars). DoD does fund for all spares associated with DoD operated elements of the system, such as Vandenberg AFB Shuttle facilities.

Question. What are the prospects that DoD might require that an Orbiter be reserved for its own missions only? If there are such prospects, when might such a decision have to be made?

Answer. Due to the limited fleet size, we believe it is important that the Orbiters maintain scheduling flexibility to enable achievement of overall operational requirements. While the DoD might require the equivalent capability of a dedicated orbiter, we believe that setting aside one (or more) orbiters for "DoD only" use would be an inefficient use of the limited Orbiter resource.

Question. Are there any circumstances under which the DoD would consider production of a fifth orbiter on its own?

Answer. No. We firmly believe that all Orbiter production should be under the auspices of NASA who has, inbeing, the government-contractor team to manage this acquisition. We believe that any other alternative would be inefficient and inimical to the objective of commonality among orbiters.

Question. Do you see a point at which DoD payload weights will exceed the launch capacity of the Shuttle? If so, would DoD consider an alternative launch vehicle?

Answer. Not in the foreseeable future. In the event such requirements develop, we would have the option to use the Shuttle's unique capabilities to support on-orbit assembly of a system that could not be deployed in a single Shuttle flight. We, of course, assume that the basic Shuttle will achieve the performance capability currently planned.

Question. Has consideration been given by DoD to "bumping" STS-9 to assure the scheduled launch of STS-10.

Answer. To satisfy critical national security needs, we require the launch of a DoD payload on STS-10 in November 1983 as currently manifested by NASA. We would hope that the delay caused by problems with STS-6 will not impact other users of Shuttle.

Question. DoD's projections of Shuttle payloads have decreased in recent estimations, adversely affecting the case for a 5th orbiter. To what do you attribute these reduced Shuttle requirements and do you agree with an assessment that these estimates are consistent with a 4 orbiter fleet?

Answer. In the early years of Shuttle operations, the DoD dropped requirements for three flights (one in 1984 and two in 1985) due to rescheduling and program redirection. Overall, based on the fiscal year 1983 President's Budget there was a prospective need for 120 DoD flights through 1994. The corresponding number based on the fiscal year 1984 President's Budget would be 117 for a 2.5 percent reduction. We do not believe that changes of this magnitude have any impact on orbiter fleet size decisions. The DoD has consistently maintained that a 3 orbiter fleet is sufficient if only DoD needs are considered.

Question. What are the approximate cost penalties for postponing a production decision on a 5th orbiter for one more year? For 2 more years? For 3 more years?

Answer. According to projections provided by NASA, to initiate procurement of OV-105 in fiscal year 1984, $200 million would be required in fiscal year 1984 with total costs estimated at $1,595 million (in fiscal year 1984 dollars). If procurement is initiated in fiscal year 1985, total costs are estimated as $1,750 million including $100 million in fiscal year 1984 for structural spares. No data are available for a 3 year delay.

Initiation of OV-105 in fiscal year 1983 is no longer possible because of the lead times required for such a procurement.

Question. Is private sector funding of a 5th orbiter an acceptable alternative to DoD?

Answer. The ultimate acceptability would depend on the terms and conditions associated with the private investment. We have nothing against the concept, in principle.

Question. What does DoD estimate should be the appropriate level for space shuttle orbiter spares acquisition for fiscal year 1984 and 1985?

Answer. The fiscal year 1984 Congressional Budget submitted by NASA includes $260 million for orbiter spares. This $260 million includes the $100M for major structural spares that is identified with the President's directive on Shuttle orbiter production capability. The NASA fiscal year 1985 budget includes $292M for orbiter spares including $120M to continue the major structual spares programs.

The DoD has not conducted an independent assessment of the adequacy of these funding levels.

Question. Under what circumstances would DoD consider bumping STS-9 for the launch of STS-10? When might such a decision have to be made?

Answer. The DoD requires launching of a national security payload in November 1983 as originally scheduled and manifested by NASA. If due to the delay in STS-6 NASA cannot accommodate the present overall schedule, we would expect NASA, as Shuttle operator, to determine what civil payload would be impacted. This determination would, in turn, identify when they must make such a decision.

Question. The major new start in the NASA aeronautics program is the Numerical Aerodynamic Simulator. Will the defense agencies be major users of this capability? If so, is there satisfaction that the NAS design is fully adequate for military aircraft design purposes?

Answer. The Numerical Aerodynamic Simulator (NAS) is envisioned to be the "Standard" for all aerodynamic computational activities in academia, industry and government agencies. Therefore, while DoD will be a user of the NAS, it is difficult at this time—until the capabilities of the NAS are defined in greater detail—to specify to what extent the DoD will use the facility.

The only concern DoD has regarding the design of the NAS involves the security level of the computations. This area is being jointly explored by NASA and DoD, with recommendations regarding security level and procedures expected in approximately six months.

Question. We are generally familiar with the support by NASA of defense aeronautics programs. Do DoD programs, such as "modern technology demonstration engine program" or "mental-matrix composite materials" support NASA's propulsion and structures programs? How do these DoD programs find their way into civilian aircraft applications?

Answer. There are several mechanisms in place to assure the coordination and mutual support of NASA and DoD Aeronautics programs. Among these are the Aeronautics Panel of the Aeronautics and Astronautics Coordinating Board (AACB), the Air Force Systems Command/NASA Interdependency Group and the Army/NASA Memorandum of Understanding which provides for the Army Aviation Research and Technology Laboratories to be co-located at the NASA centers. The results of DoD programs find their way into civil aircraft applications primarily through the industry. The same contractors build military and civilian aircraft and engines. The normal course of events is that development of a civil version of the aircraft or component occurs sometime after the military version has entered service. Some examples are: the GE CF-6 high by-pass tubofan was derived from the TF-39 which powers the Lockheed C-5 aircraft; and, the GE CT-7 series shaft engines are civilian derivatives of the T-700 series engines developed by the Army for the UH-60 and H-64 helicopters.

Question. Your testimony indicates that you will "work closely with NASA to assist in whatever way we can to regain the test capability of the 40 x 80 foot wind tunnel (at Ames) as soon as practical." Would that assistance extend to shared funding, particularly if delays are encountered in completion of the work?

Answer. We have closely coordinated the schedule and costs to repair the 40 x 80 foot wind tunnel with NASA. They have informed us that they have sufficient funds indentified to complete the repair, and furthermore it is our understanding that additional funds will not speed up the repair due to the method by which the fan blades are fabricated. Our offer of assistance could include providing defense priority for any domestic procurements, and also stating the importance of the facility to defense needs to allow duty-free overseas procurement.

Question. Are you satisfied that the aeronautics budgets for DoD and NASA fulfill the federal responsibilities for support of aeronautics research and technology as announced by the President's Science Advisor last November?

Answer. In fiscal year 1984, the DoD and NASA will spend approximately one billion dollars on aeronautics research and technology. While there may be a few isolated circumstances where some disagreement exists regarding the priorities of the activities being pursued, the major thrust of these efforts is to achieve the improvements in air vehicle characteristics as stated in the Office of Science and Technology Policy report issued last November. This year as in past years, we will make significant progress toward achieving those benefits. Yes, I am satisfied that the federal responsibilities in aeronautics research and technology are being fulfilled.

Question. NASA and DoD are involved in two joint aeronautic projects: (1) NASA/Air Force project on the advanced technology integration of the F-16 aircraft, and (2) a NASA/Defense Advanced Research Projects Agency (DARPA) project to develop the technology base for the X-wing/rotor concept. How are the responsibilities, costs, and results shared in these two projects?

Answer. (1) In the NASA/Air Force Advanced Figher Technology Integration project on the F-16 (AFTI/F016), the Air Force is responsible for all contractor modifications and flight tests; operational type flight testing; and, provision of aircraft spares during NASA flight testing. NASA is responsible for selected wind tunnel tests, simulations, and research type flight testing. (2) The responsibilities and costs for the X-wing rotor program are shared equally by NASA and DARPA through a Memorandum of Agreement. The shared responsibilities include a joint program office manned by both NASA and DoD personnel.

In both cases the results of all the tests are shared equally and will be available for dissemination through the aeronautics community, subject of course to any security limitations.

Question. To what extend does DoD rely on NASA research and development in space applications such as communications, navigation, earth remote sensing, and meteorology? How would this dependence be affected if operational responsibilities, e.g. for Landsat, are transferred to the private sector? Does DoD depend on its own continuing R&D in such circumstances?

Answer. For development of those applications that are uniquely military in nature, the DoD relies on DoD R&D organizations and private contractors. Activities that are mutually beneficial to both civil and military applications are handled on a case by case basis to determine funding levels and overall management responsibility. In general, NASA's emphasis has been on basic scientific understanding of terrestrial processes whereas the DoD has stressed contributions to operational missions. Within the Aeronautics and Astronautics Coordinating Board, a joint NASA/DoD activity, and its various sub-panels, there are provisions for mutually exchanging ideas and for coordinating and planning future activities of both organizations.

DoD reliance on NASA R&D should not be affected by the transfer of operational systems such as Landsat to the private sector. However, NASA R&D is expected to continue to enhance or upgrade those operational systems. Where areas of mutual R&D interest are identified, we will continue to work together to define joint endeavors that will further our respective goals within the guidelines of national security, policy, and non-duplication of commercially available data products.

Question. Did the transfer of communications satellites responsibilities from NASA to the private sector present any problems to the DoD in maintaining a strong related R&D capability?

Answer. The transfer of all communications satellite responsibility from NASA to the private sector does create some problems in that it is more difficult to focus technology into particular areas of interest by working with individual elements of the private sector than by working through a single responsible agent. In addition, we believe that having NASA involved in advanced communications satellite activities such as ACTs helps provide a good technical base that the DoD can draw upon. Many of the components and technologies are very similar. Many are not. MILSATCOM systems must emphasize survivability and endurance while that is not a driver in NASA's program.

Question. Your testimony indicates that DoD strategy "provides for expendable launch vehicle backups for the first two years of Shuttle operations from the Kennedy launch site" and that this backup capability will be provided by the newly developed TITAN III (34)D boosters.

You also indicate that, with the exception of one program, the transition of all national security spacecraft from their current expendable launch vehicles to the Shuttle will occur by fiscal year 1989, or more likely fiscal year 1986. NASA considers that their Space Shuttle became operational in November 1982, so there is a question about what is meant by the transition period.

Could you clarify when and how you plan to terminate Expendable Launch Vehicle acquisitions and commit entirely to the Space Shuttle launch vehicle?

Answer. Our plan is to discontinue expendable launch vehicle production following the successful completion of STS-6 which will demonstrate the flightworthiness of the second orbiter and lightweight external tank, the compatibility of the Inertial Upper Stage with other elements of the Space Transportation System, and the operational readiness of additional launch processing elements such as the second Mobile Launch Platform. STS-6 is currently scheduled for Spring 1983. Termination at this point will provide sufficient TITAN launch vehicles to satisfy prime mission requirements as well as satisfy our backup criteria. The baseline plan envisions not completing TITAN III (34)D vehicles No. 17 and No. 18 and reprograming the funds appropriated for these vehicles in our fiscal year 1983 budget to other priority DoD needs. Termination of vehicles No. 15 and No. 16 is also under consideration. The last TITAN launch from Cape Canaveral is projected for fiscal year 1986 and the last DoD Atlas Centaur launch is projected for fiscal year 1987. The last TITAN launch from Vandenberg AFB is projeced for fiscal year 1986, with Atlas E launches for the Defense Meteorological Satellite Program continuing through fiscal year 1988.

The DoD refers to the "transition period" as the span of time from first DoD use of Shuttle to last DoD use of expendable launch vehicles including prospective backups.

Question. You say in your testimony that "in some critical programs we have already optimized our spacecraft for the Shuttle and as such, we can no longer fly them on current expendables." Would this incompatibility with the expendables be generally the case? Our understanding is that Space Trans plans to offer a Shuttle-compatible TITAN (34) D as a commercial vehicle. If the need arose, could this vehicle be adapted for defense payloads?

Answer. Incompatibility with expendables (TITANS) is not currently the general case for DoD payloads. However, we are evolving toward this posture, and have procured adequate TITANS for those remaining spacecraft that are compatible with this launch vehicle. With respect to use of the Space Trans proposed TITAN configuration, it might be useful in limited applications. We do not believe there is any plan to make this configuration available on the West Coast and the performance would be less than that of the current TITAN III (34) D because of the burden of the large diameter payload fairing required for Shuttle compatibility. These two considerations severely limit its attractiveness for DoD missions.

Question. Your testimony says that a decision regarding TITAN production will be made "if STS-6 is successful." What would constitute "successful" for purposes of this decision?

Answer. We would consider a "successful" mission one that demonstrated nominal performance of all elements of the system. STS-6 is particularly important because it will employ, for the first time, the second operational Orbiter and lightweight External Tank, and demonstrate the compatibility of the Inertial Upper Stage with other elements of the Space Transportation System for geosynchronous spacecraft deployments.

Question. Is there any concern that abandoning ELV's in favor of the Space Shuttle would leave the defense space program particularly vulnerable to the loss of an orbiter or critical spare parts?

Answer. Yes. That is precisely why we structured a transition plan that is keyed to orbiter deliveries. The third orbiter will be delivered in September 1983 and the fourth in December 1984. Therefore, we will have sufficient orbiters to accomplish the DoD missions (given DoD priority) even on a contingency basis at the completion of transition. We remain concerned about the adequacy of spare parts and are encouraged by NASA attention to this issue.

Question. You express concern in your testimony about the "adequacy of continued DoD launch support with both TITAN and ATLAS/CENTAUR vehicles through the period prior to Shuttle transition and the potential impacts—both positive and negative—of additional launch alternatives on the Shuttle program." Would you clarify or elaborate this statement?

Answer. We understand that some of the proposals to "commercialize" expendable launch vehicles envision a near-term take over of launch operations including current commitments for DoD launches. Before we would support any such proposal, we would want to make absolutely certain that national security launch requirements would be met.

Commercialization could potentially impact the Shuttle program both positively and negatively. Commercial expendable launch vehicles could supplement Shuttle capabilities during transition (and perhaps longer) and, as I pointed out in my statement, provide limited backup without continued government investment as well as the potential for the U.S. to capture a greater share of the commercial and international market. The prospective negative impact includes consideration of the introduction of additional competition with the Shuttle for the launch services market and the influence that could have on the cost of Shuttle operations. We are working to understand these issues better to provide a sound basis for our commerialization policies.

Question. Your testimony described DoD's planned uses of the IUS and Centaur G upper stages. You indicated some shifts from IUS to Centaur G but that "our remaining spacecraft programs will remain on the IUS at least for the near term." Does that mean that the DoD may need fewer IUS's later than have been contemplated so far?

Answer. Because of the decision for some DoD space programs to use Centaur, there will be a one-for-one reduction in the numbers of IUS's required. The ultimate viability of the IUS programs will depend on its economic competitiveness for payloads within its performance capabilities.

Question. Is there any joint planning going on between NASA and DoD for a higher energy upper stage than Centaur? Have both civilan and defense applications been identified?

Answer. Selection of the Centaur for NASA and DoD applications exceeding the performance of the IUS has curtailed planning for the previously envisioned higher energy upper stage (HEUS). We continue to work with NASA in defining concepts for future potential applications such as reusable or manned orbit vehicles, but we have identified no firm requirements necessitating near-term developments.

Question. If CSOC is not completed on schedule in 1987, can DoD turn to Johnson Space Center for launch operation controls? How would the NASA schedule be affected in accommodating the DoD operations? Have contingency plans been made by NASA and DoD?

Answer. If CSOC is not completed by 1987, JSC can continue to support DoD operations albeit with less than desired security and perhaps at the expense of civil missions.

It is not clear at this time how the NASA launch schedule would be affected. Generally, JSC is becomming more optimistic about the number of DoD missions they could support as they gain operational experience and the number of civil missions becomes more conservative. Commercialization of domestic expendable launch vehicles could also reduce the demand for NASA shuttle operations.

No specific contingency plans have been made, but we believe we retain the option, through exercise of priority, if necessary, to guarantee support of national security missions until the CSOC shuttle planning and control capability is operational.

Question. You have just created a new Space Technology Center at Kirkland Air Force Base in New Mexico to "focus on the major scientific disciplines for launch vehicle and spacecraft technology." How will this realignment affect the dependence of DoD on work which is conducted in the NASA centers? In other words, is the Space Technology Center a step toward a DoD capability which is parallel to or independent of existing NASA capabilities?

Answer. The establishment of the Space Technology Center was an organizational realignment consolidating three existing Air Force laboratories—the Rocket Propulsion Lab, the Geophysics Lab, and the Weapons Lab—under a single headquarters reporing to the Commander of the Air Force's Space Division. This consolidation did not change the scope of activities of the individual components, but was intended to facilitate coordination among AF R&D efforts which are devoted to military requirements. The presently established cooperative working relationships with NASA will continue.

NASA AUTHORIZATION FOR FISCAL YEAR 1984

WEDNESDAY, MARCH 9, 1983

U.S. Senate,
Committee on Commerce, Science, and
Transportation,
Subcommittee on Science, Technology, and Space,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:40 a.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator Groton. I am pleased to chair these hearings of the Subcommittee on Science, Technology, and Space in this, the 25th anniversary year of NASA. This Nation has become increasingly aware of the contributions which NASA has made and is making to our technological and scientific leadership. Partly as a result, our high technology exports now rank second only to agricultural products.

Equally important, NASA's achievements have been enormously important to our national stature and aspirations. In the 2 years that I have been in the Congress, the Space Shuttle has progressed from its stunning maiden voyage to an operational system. The first joint effort between NASA and industry has been undertaken to prove the commercial possibilities of space. Images of the rings of Saturn have been returned from space. Images of such clarity that previously unsuspected details have both amazed and puzzled observers.

Today, we will be considering the NASA authorization for fiscal year 1984. There is much to recommend the budget and programs which the President has proposed. The attention given to space, science and applications, including planetary exploration and to aeronautics is closer to the position which this committee has held in recent years. The first new planetary start in 5 years, the Venus Radar Mapping Mission, is a very welcome initiative.

Increases proposed for the Explorer program are an important commitment to providing affordable opportunities for smaller experiments on free-flying spacecraft. These missions comprise the majority of those conducted by our universities and national laboratories.

A most exciting new start, one which the subcommittee has supported in recent years, is the Numerical Aerodynamic Simulator. I do not have to understand the mathematics of three-dimensional fluid dynamics to appreciate the importance which this capability will have in new aircraft design and, consequently, to the competitive posture of the United States in this important international market.

That importance was reinforced by the report in this morning's Washington Post that Japan's Ministry of International Trade and Industry (MITI) chose the aerospace industry as one in which Japan could achieve technological progress and long-term growth by moving in on a field previously dominated by other industrialized nations, just as (MITI) did with electronics and computers.

The article goes on to describe a number of joint agreements which the Japanese have concluded with U.S. manufacturers for development and production of advanced propulsion systems in aircraft. It seems clear the advantages to the Japanese in these agreements are notably greater than those to this country, and I will include a copy of that Washington Post article in this statement.

[The article referred to follows:]

[From the Washington Post, Mar. 9, 1983]

JAPAN PLANNING MAJOR MOVE INTO AEROSPACE INDUSTRY

(By Thomas W. Lippman)

The government of Japan has organized, and is helping to finance, a long-range campaign to carve out a major place in the worldwide aerospace industry for Japanese manufacturers, Commerce Department researchers reported yesterday.

Japan's Ministry of International Trade and Industry (MITI) chose the aerospace industry as one in which Japan could achieve technology progress and long-term growth by moving in on a field previously dominated by other industrialized nations—just as MITI did with electronics and computers—the report says.

The alleged targeting of the U.S. electronics and computer industry—which has provoked loud complaints from U.S. manufacturers—is continuing as MITI seeks the lead in the development of the next generation of those products, the report says.

"Currently, certain high-priority projects in areas such as software, the fifth-generation computer and the supercomputer are receiving unprecedented attention," including loans, subsidies, tax breaks and outright grants from MITI to the manufacturers," the report says.

According to Robert L. Eckelmann and Lester A. Davis of the International Trade Administration's trade research division, the same techniques of financing and organization now are being applied to the aerospace industry, and the Japanese are being aided—if unwittingly—by U.S. manufacturers who have brought Japanese firms in on coproduction deals.

As if to confirm this analysis, the Pratt & Whitney division of United Technologies Corp. announced yesterday that it has reached an agreement to undertake joint development of a new commercial jet engine with a Japanese consortium and with British, German and Italian firms.

It is no secret to aerospace executives that Japan's unique government-industry partnership has begun to build up Japan's weak aerospace sector. Cessna Aircraft Corp., for example, already has reported losing some sales to Mitsubishi Heavy Industries' new executive jet, the nine-seat diamond.

The scope of Japan's aerospace effort, however, has been less-well-publicized in this country than MITI's well-documented legal and financial assistance to computer manufacturers.

According to the Commerce report, the Japanese government is expected to contribute $581.7 million in the 1981-1987 period to assist five major aerospace projects.

These are the "YX," or the 15 percent share of the development of Boeing's 767 commercial jet subcontracted to Mitsubishi, Kawasaki Heavy Industries and Fuji Heavy Industries; a short-takeoff-and-landing (STOL) plane scheduled for test fight this year; a high-performance fan jet known as the FJR 710; the "YXX," or "next-generation" medium-sized commercial airliner; and the RJ-500 engine, a joint project with Rolls-Royce to develop a new commercial fan jet.

Yesterday's announcement from Pratt & Whitney said the technology of the RJ-500 will be incorporated into the engine developed by the five-nation consortium. The British-Japanese venture will be responsible for the fan and high-pressure compressor of the new engine, the company said.

In an effort to build up their own expertise and avoid taking losses in developing commercial airliners on speculation, that is, without orders, the Japanese have agreed to emphasize joint development and production efforts with manufacturers in other nations, the report says.

It says that this tactic offers "a means of building up aerospace production capacity, gaining valuable technology expertise and work-force training, creating sales and follow-up networks, and obtaining some protection, through the major partner, from the intense competition in the transport market."

According to this report and others, the Japanese already have acquired extensive technological expertise from their joint production agreements on the Boeing 767, the F15 fighter and the P3 antisubmarine plane, all developed by American companies.

It is far from a foregone conclusion, however, that the Japanese will be able to make themselves competitive in worldwide aerospace development, the report notes.

Even if Japan stimulates its aerospace industry by substantially increasing defense spending, as the United States is pressuring it to do, the Japanese face serious constraints in developing commercially competitive products, the Commerce report says. Among the problems are a "minimal domestic market" for commercial jets, a shortage of trained personnel, and a lack of an overseas marketing and servicing network.

Senator GORTON. There are, however, issues which must still be addressed. The most prominent is that of prospects for a fifth orbiter. The proposed fiscal year 1984 budget provides only for the acquisition of structural spare parts for a four-orbiter fleet. The President's science adviser has recently suggested that there is no longer a need for a fifth orbiter.

This committee has considered that a fifth orbiter for the Shuttle fleet is essential and has proposed funding in previous years for procurement of long lead items as well as outyear funding for production.

Another element of interest in the space budget is the provision for research and analysis, which directly supports experimental and theoretical research at universities, as well as conceptual and experimental developments which form the basis of new missions. Research and analysis may lack the glamour of the planetary missions, as an example, but the scientific return on the modest investment can be very large. In fact, it is hard to justify the high cost of collecting this data if that data is not readily accessible and used.

As the Space Shuttle becomes operational, attention is turning to the next major space initiative, and a space station appears to be the most logical step. This is an undeniably exciting prospect which raises a number of important issues. Can a major effort such as a space station be undertaken without unbalancing our national space effort? We have, for example, witnessed the pressures on space science and especially planetary exploration as development of the space transportation system required substantial commitments of NASA's resources.

Clearly, these are only some of the issues in which this committee has an interest. We are very pleased, therefore, to welcome Dr. James Beggs, NASA Administrator; Dr. Hans Mark, Deputy Administrator; and Mr. Thomas Newman, NASA Comptroller, to this hearing to address the fiscal year 1984 authorization for NASA.

I also have to apologize to the three witnesses. The Budget Committee begins its markup of the first budget resolution in 15 minutes, and it has the unique no proxy rule. So very shortly after 10 o'clock, I must leave you, and most of your testimony will be heard and the questions asked by my distinguished colleague, Senator Trible.

Before I turn it over to you, Dr. Beggs—Paul, do you have an opening statement?

Senator TRIBLE. No, Mr. Chairman, thank you.

Senator GORTON. Senator Heflin has an opening statement.

OPENING STATEMENT BY SENATOR HEFLIN

Senator HEFLIN. Mr. Chairman, I join you in these hearings to consider NASA's budget request for fiscal year 1984. I am particularly pleased to have my new assignment as the ranking Democrat on this subcommittee. In this role I look forward to reviewing NASA programs in the same cooperative, bipartisan spirit that has characterized this subcommittee.

As I look over the specifics of the budget request, I am concerned over whether the overall 3.9-percent increase in NASA's budget will be adequate, particularly when inflation is at least twice that figure. Dr. Keyworth's explanation to me the other day of why it was so low, especially when compared to DOD and NSF, was that the administration was supporting the best talent. Well, I know of few agencies that have done as much and could do even more with proper support.

I am pleased that the budget does allow for some needed efforts. The lower requirements for Shuttle production make some money available for other efforts. While no commitment to a fifth Shuttle Orbiter is made, money is included for spares that could keep the production option open. There are two new starts in space science, continued support for the advanced communications satellite and the initiation of the numerical aerodynamic simulator program so important to advance the testing of aeronautic designs. Mr. Beggs, I must congratulate you and the administration for the progress you've made.

I should be frank; I do have some questions, if not concerns, about other elements of your budget.

To begin with, I welcome at long last the administration's willingness to increase rather than decrease its support of aeronautical research and technology. But I still do not comprehend the inability of the OMB to understand the importance of NASA's high risk technology development efforts that are so crucial to our aviation industry. No individual firm in the industry is able to perform the work, and antitrust laws prevent cooperative ventures. The OMB posture still seems to be contrary to the NASA Act of 1958 that directs NASA to preserve "the role of the United States as a leader in aeronautical science * * * and in the application thereof * * *." More to the point, however, this lack of OMB support could set the stage for our highly important aviation industry to follow in the footsteps of certain declining U.S. industries.

In the space area, I have a number of questions which I hope the NASA and public witnesses will be able to address. In particular I'm interested in the following areas:

Are we using the Shuttle effectively, and is there anything more we need to be doing to operate it on a sound businesslike basis?

What can we do to encourage priviate sector investments in the space program and generally how do we promote greater efforts in space commercialization?

Why do we fund certain space applications programs at such low levels when the economic potential is so significant? I am particularly referring to the materials processing and communications program.

Space stations—Where do they fit into the Nation's future and the future of NASA? Are we doing enough in this area?

I will have a number of specific questions for our witnesses later. I look forward to hearing the NASA testimony today and the statements by our public witnesses next week.

Thank you, Mr. Chairman. I look forward to working with you on these matters.

Senator GORTON. Thank you very much. At this point, I will enter a statement of Senator Hollings as a part of the opening statements herein.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Today we hold hearings to consider NASA's budget request for fiscal year 1984. Just 25 years ago this agency was born, and it has produced an incredible number of accomplishments. It has totally revolutionized the way we view ourselves and how we live. No agency or institution symbolizes so well America's great history of spirit, excellence and can-do attitude.

We in the United States are very proud of our space program. I have been a long time supporter of the space program. In my new role as Ranking Democrat on the Committee, I believe I will have a greater opportunity to review our space program. I will be working closely with Senators Packwood and Gorton and with the Ranking Democrat on the Subcommittee, Senator Heflin.

Mr. Beggs, NASA and the nation is fortunate to have yet another able Administrator at the helm. Your Agency is in pretty good hands up here in the Senate as well. I wan't so sure 6 years ago when we reorganized the Senate Committee structure and abolished the old Space Committee. I told Dr. Fletcher then that he'd better watch out, the Senate just demoted NASA to a Subcommittee, and we may lose it altogether.

Fortunately, the Committee has been an active supporter. We nourished the shuttle program along, and 2 years ago you proved that the faith we and others in the country had was not misplaced. You successfully flew the first Shuttle mission in April 1981. I know you've had some new technical problems with the Shuttle, but that can happen in such a complex R&D program.

This month, hopefully you'll fly your 6th mission. I've got a seed company in South Carolina counting on it. They're doing some interesting experiments on the growth of seeds in zero gravity. I must say, when I looked over the intial flight plans for the Shuttle, I was beginning to believe that there would be more space Shuttles in service than there are airline flights from National Airport to Charleston.

It's becoming pretty clear to us in Congress that the OMB has seen to it that you won't fly that much. They're taking away your missions, your orbiters and any real opportunity to make the Shuttle an economic system. It's not hard to understand why they think that way. They think from year to year, and this year we're all looking at a Federal deficit of $200 million. In their view every dollar outlay adds to the deficit. They don't factor in the benefits and revenues generated by that dollar investment.

The 3.9-percent increase that OMB allowed in your budget doesn't even keep up with inflation. DOD's R&D effort is going up 29 percent; NSF is up 18 percent. If the President really wanted to unleash American ingenuity and maintain our technological leadership—as he claims, he sure missed an opportunity in NASA's budget this year. Maybe I just don't understand. I've always believed in supporting success. Yet the more NASA accomplishes, the less it seems to get in its budget. I've looked over your budget, and it could be worse. It does suffer more in some areas however, and I hope this committee will correct those. Among other things: Now that the Shuttle is moving to an operational status, we need to make sure the program is run on a sound business basis; we need to make firmer commitments in space applications, which at this point is both the most important and the most underfunded of all NASA space efforts; and we need to remedy the lack of emphasis in civilian aeronautics R&D, the prop fan in particular. I just don't understand this Administration's stubbornness. Do they want our nation's aviation industry to follow in the footsteps of our steel, automobile and maritime industries?

The U.S. is still preeminent in space efforts, and we need to make sure this budget maintains our position. As the Office of Technology Assessment reports, we're facing increased competition for that leadership. This Committee must recognize that money is not the only factor to keep the vitality of the Agency alive. We must know where we're going however, and we must also find more ways for private sector participation. On this latter point, I recently introduced S. 560, the Private Satellite Launching Authorization Act, to help stimulate private sector efforts.

Finally, Mr. Chairman, I'd like to spend a moment looking toward tomorrow, beyond fiscal year 1984. We sometimes lose our perspective when we deal just with an annual authorization.

In just a few years, this country will celebrate its 500th year since discovery. This nation, let alone NASA, may be quite different then. In these hearings, we'll not be able to reflect upon what NASA has done nor where the space program should be headed—is it drifting, what issues does it face. As an effort to focus on the future of the space program, I soon will be introducing a bill to establish a Presidential Commission on Space.

It's time we once again support our creative talent and let our national spirits soar. NASA is not the only place where the drive to succeed exists, but it is a darn good place on which to build. As George Will wrote, "The flight of the Columbia went forward in spite of the country's cheese-paring spirit regarding support of the space program. Perhaps this flight can rekindle the spirit the futures deserves, the spirit of the American past . . . you ain't seen nothing yet." I agree with that view, and I hope this Committee will work toward that end.

Thank you.

STATEMENT OF HON. JAMES M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. HANS MARK, DEPUTY ADMINISTRATOR; AND C. THOMAS NEWMAN, COMPTROLLER

Mr. BEGGS. Thank you, Mr. Chairman. I have a longer written statement that I would like to submit for the record with your permission, and would like to present this brief summary at the hearing this morning.

Senator GORTON. Without objection, your entire written statement will be included in the record.

Mr. BEGGS. Thank you, Mr. Chairman, and members of the committee. It is a pleasure for me to appear before this distinguished committee to present President Reagan's budget request for NASA for fiscal year 1984. The total request is $7.1 billion, of which $5.7 billion is research and development, and $150 million for construction of facilities and $1.25 billion for research and program management. A chart summarizing NASA's fiscal year 1984 request is appended to my statement.

I am particularly proud to be at NASA in 1983 to celebrate its 25th anniversary. During the 25 years since the U.S. entered the space age, our space program has grown from the 14 kilogram Explorer launched in January 1958 to a truly reusable space transportation system (STS).

Mr. Chairman, you have before you a small folder which has some of the highlights of the program, and since I have not had the opportunity to address this particular group before, I thought at this time I might run through what we do and where we do it. NASA operates through 10 field installations. It is quite decentralized in its operating philosophy. The centers that we operate are generally divided between the various missions that NASA is responsible for.

NASA is charged by the Congress to do research and development in the aeronautical and space sciences, to do exploratory work in space science and exploration of the solar system and the universe, and to work in the area of manned space flight and the use of equipment in the further exploitation of space for the benefit of man.

The centers are, therefore, divided pretty much in that way with the Langley, Lewis, and Ames Research Centers charged with the aeronautical and space research, the Goddard Space Flight Center and Jet Propulsion Laboratory charged with the science and exploration activities of the agency, and the Johnson, Marshall and Kennedy Space Centers charged with the manned space activities.

The program, as I said, started 25 years ago with the launch of Explorer I. That was the first in a long and distinguished series of Explorers which is ongoing today, and, indeed, we have proposals in the 1984 budget for continuation of that Explorer line. It has been an extremely successful science program and has, I think, shown the way for the rest of the world in the exploitation of space for the expansion of man's knowledge.

The Pioneer series of missions, which started back in the early 1960's, was our first exploration of the solar system, and that has culminated in two Voyager flights which have explored all of the outer primordial planets of the solar system, or will have explored them all because it is on its way to Uranus. That spacecraft will arrive at Uranus in 1986 and then beyond that it will go to Neptune, we hope, because we believe it will live long enough to get to Neptune.

We will have seen, therefore, at close range all of the planets of our solar system with Explorer-type spacecraft by the end of the decade except for Pluto. So it has been a very, very successful program and has added to our knowledge not only of the solar system, but has given us a new insight as to the many mysteries of the universe.

The manned program started with Mercury in the early 1960's, proceeded through Project Gemini, which was a necessary step in learning more about the operation of more complex missions including a rendezvous in space, and then proceeded to the very successful Apollo program. In all we landed 12 men on the Moon and there were another dozen that circumnavigated the Moon. It was done in the time that was allotted. President Kennedy stated we should do it within the decade of the 1960's and, indeed, we did. It cost approximately $23.5 billion, which was within the estimates that had been made early on.

After the Apollo, we proceeded to the exploration and exploitation of near space with the Skylab. Skylab spent in three different missions, a total of 167 days in space and it was our first opportunity to start to understand the use of space in industrialization. We did materials processing work, we did a lot of observation of the Earth and the Sun from Skylab, and we learned a lot which we are still drawing on to configure our programs in the current day and plans for the future.

Starting in 1972, we proceeded with the development of the Shuttle with the initial launch of that system last year. We have what we believe to be a very successful reusable system which will provide transportation to and from space for the next 20 years. We are proceeding with a number of programs in the use of the Shuttle, both scientifically and to provide further industrialization. Lots of various experiments will be carried on a space-available basis and on dedicated missions using the Spacelab which was designed and developed by the European Space Agency (ESA).

That, I think illustrates another important part of this program, and that is the very extensive international cooperation that we have had through the 25-year history of NASA.

In all, NASA has signed over 1000 agreements with 100 different countries for the sharing of data and joint space research and technology. Foreign countries have contributed significantly to many of our missions. The Spacelab, for example, which was an ESA initiative, involved the expenditure of over $1 billion on the development of that system. This system was presented to us a little over a year ago and will be our prime system for the scientific experimentation using the Shuttle.

We have proceeded on to a number of applications programs which have become commonplace. We all know about the meteorological satellites and the communications satellites—perhaps not so well known are the two that I have mentioned. The search and rescue activity will be a worldwide system enabling the location of in very, very short time periods, downed aircraft or ships in distress. That is another international program, a cooperative activity with the Soviet Union, the French, and the Canadians. The initial capability was put up by the Soviets and we have already rescued 19 people, most of whom would not have been found unless we had this capability.

We will be launching on STS–6 the first of our tracking and data relay satellites (TDRS). This will consist of a system in space to provide almost complete realtime coverage of all spacecraft in Earth orbit. We believe that it will be a very successful extension of our ground-based tracking activities into the 1990's and beyond.

Landsat has been a very successful program of Earth observations. The Landsat-4 has the capability to obtain about 20 times the information content of the previous satellites. It is being used by a number on different groups or activities in this country including mineral exploration companies. Local and State governments use it for drawing such things as tax maps, as well as management of water resources and other activities.

Lastly, our contributions to civil aircraft and military aircraft have been extensive, not only for the 25 years that NASA has been in existence, but for the almost 70 years that our predecessor agency, the NACA, and now NASA has been in existence. Almost every civil aircraft and military aircraft currently in operation carries in it quite a lot of NASA technology. We continue a very close partnership both with the civil aircraft and the military aircraft developers in order that we remain at the cutting edge of technology. Our aircraft are superior to any others developed in the world, and I believe they still are and will remain so for the future.

As you know, Mr. Chairman, the launch of STS-6 has been delayed from its original planned launch date of January 28 to a date early next month. The delay is as a result of the discovery of several small leaks in the Shuttle main engines. These leaks will be repaired on a set of engines which will be reinstalled in the Challenger. We should be able to proceed with STS-6 in April. In order to minimize delay of subsequent flights, we are developing operational tests and procedures to assure that future flights will not be subject to this type of delay.

Now, I would like to spend a few minutes discussing some of the achievements of the past year—achievements which have been very significant, indeed, and which would not have been possible without the strong and continued support of the Congress.

In 1982, the Space Shuttle orbiter *Columbia* made three successful orbital flights, and during each flight significant progress was made in understanding the operational features of the Shuttle system. This initial phase of the STS flight program culminated with the first operational flight in November 1982, when two commercial communications satellites were launched. There is no doubt in my mind, Mr. Chairman, that the investment this Nation has made in the Space Shuttle will pay off handsomely. We now know enough about the system so that I can make this statement with great confidence.

A new Earth observation satellite, Landsat-4, was placed in Earth orbit in July 1982. Its operations have been spectacularly successful until a recent anomaly occurred disrupting correct readout of the thematic mapper data through the spacecraft's X-band communication link. This link was to have transmitted thematic mapper data directly to the ground before the TDRSS became operational. In the event we are unable to correct this communication problem, information will be once again acquired when TDRSS becomes available later this year. The satellite's new thematic mapper has provided information of a quality exceeding the original specifications, including valuable information for the geophysical sciences as well as excellent data for mapping and Earth resources assessment.

In aeronautics, the Department of Defense (DOD) has recognized the importance of NASA's technical contributions by considering NASA's tilt-rotor aircraft concept as a prime contender for the new joint service JVX vertical takeoff and landing aircraft. Also, two large new aeronautical facilities are nearing completion—the National Transonic Facility at the Langley Research Center and the new 80- by 120-foot addition to the 40- by 80-foot subsonic wind tunnel at the Ames Research Center. Completion of operational tests and checkout of the new 80- by 120-foot leg has recently suffered a setback, however, because of an accident during testing. The facility is expected to be operational in about 2 years.

This is just a brief overview of a few of the technical achievements of 1982. The list is really much longer. I will talk in more detail about some of the things that have been accomplished later on.

On July 4, 1982, President Reagan issued a policy statement which outlines basic U.S. goals for activities in space. These goals are to strengthen the security of the United States, to maintain U.S. space leadership, to obtain economical and scientific benefits through the exploitation of space, to expand U.S. private sector investment and involvement in civil space and space-related activities, to promote international cooperative activities in the national interest, and, finally, to cooperate with other nations in maintaining freedom of space for activities which enhance the security and welfare of mankind.

The NASA budget request for fiscal year 1984, which I am addressing today, is designed to achieve the objectives outlined in President Reagan's space policy. The key to leadership in space is to have efficient and effective ways of getting there. The President's space policy strongly supports the Space Shuttle program and calls the Shuttle the primary space launch system for both U.S. national security and civil government missions.

NASA's proposed fiscal year 1984 budget fully supports a four-orbiter fleet with enough structural and subsystem spares to make certain the fleet is able to survive serious delays or accidents. Our proposal will also reduce the leadtime for expansion or replacement of the four-orbiter fleet if and when operational demands require.

NASA's first priority, Mr. Chairman, remains to make the Space Shuttle system fully operational as rapidly as possible. We will also continue to explore new ways of employing the full capability of the Shuttle. Later on this year, we are scheduled to fly the first Spacelab mission, which is an important demonstration of new capabilities represented by the Space Shuttle The Spacelab, developed and contributed to NASA by the European Space Agency, represents an important international activity consistent with the President's space policy. NASA policy has recently been revised to expand opportunities for the sponsors of Shuttle payloads to nominate the payload specialists to fly with them. President Reagan has invited Brazilian and Japanese payload specialists to fly aboard the Shuttle. In addition, Australia plans to fly one, and Canada is considering NASA's offer to fly one.

In my testimony before this committee last year, I said that the Space Telescope will be the most important scientific instrument we have ever flown. I continue to believe that this is true, and NASA's fiscal year 1984 budget request provides priority support to this very important development effort.

As might be expected in a program of this complexity, we are continuing to experience technical problems, particularly in the optical telescope assembly development activities, which will most likely impact the scheduled launch and runout cost of the Space Telescope. We are currently reviewing a range of alternatives for rephasing the work to minimize the cost and the schedule impact. As soon as our evaluation is completed, we will inform the committee of our proposed actions.

Another measure of leadership in space is the continued enterprise of planetary exploration. We have included in the proposed fiscal year 1984 budget the initiation of a new program to map the surface of the planet Venus, using radar-imaging techniques. Within our overall strategy for planetary exploration, this initiative, the Venus radar mapper, estimated to cost in the $350 million range, replaces at a much lower cost the Venus orbiting imaging radar mission authorized by the Congress to begin in fiscal year 1982.

The advanced communications technology Satellite (ACTS) calls for development and flight testing of the high risk technology needed to insure continued U.S. preeminence in the field of satellite communication. The decision to propose the ACTS program is the result of extensive consultation with the communications carriers and satellite system suppliers, coupled with support from the Congress. The ACTS program will involve a novel procurement approach including a cost/risk-sharing arrangement with industry which is expected to provide significant cost savings to the Government.

Another goal of the President's space policy is to expand private sector investment and involvement in space activities. NASA has received proposals from the private sector to fund and/or operate launch vehicles. We are reviewing these proposals very carefully to determine cost and benefits, launch and tracking requirements, safety and security as well as international considerations.

In November 1982, the President's Office of Science and Technology Policy released a document entitled, "Aeronautical Research and Technology Policy." The aeronautics program included in the NASA fiscal year 1984 budget request reflects many recommendations contained in this important policy statement. The most important facet of the administration's new aeronautics policy is the recognition that a strong aeronautics industry is absolutely essential for both the national security and health of our economy. In concert with this policy, we are submitting a fiscal year 1984 budget request which continues to emphasize a strong aeronautical research and technology program including a strengthened fundamental research program which will continue to provide the technical base upon which our future aircraft designs can be based.

The centerpiece of our proposed aeronautics program in fiscal year 1984 is the new numerical aerodynamical simulation (NAS) activity which will be developed over the course of the next few years. The NAS capability will include a large computer system which will make it possible to perform most of the calculations required to design new aircraft with sufficient accuracy and reliability to significantly reduce the long and expensive process of wind tunnel and flight testing now necessary. The investment made in NAS will provide incentives for various elements of the computer industry to produce machines which will be able to take advantage of major commercial applications. Development of this kind will enhance the competitive posture of the United States in this important international market.

In the fiscal year 1984 budget before you, there is a substantial increase in funding for construction of facilities; $150 million as compared to approximately $100 million in fiscal year 1983. We also are proposing the maintenance of the same number of civil service positions in fiscal year 1984 as we have in fiscal year 1983.

In the past year, Mr. Chairman, concern has been expressed in the press and in the Congress about the appropriate relationship between NASA and those elements of the national security establishment with responsibility for space operations. I would like to take this opportunity to state categorically that this administration is strongly committed to separate space programs, one dealing with the civil sector operations and the other with those related to national security. The President's space policy is very clear on this point, stating that the U.S. space program will be comprised of two separate and distinct but strongly interacting programs, national security and civil. Close coordination, cooperation, and information exchange will be maintained among these programs to avoid unnecessary duplication. We have continued to maintain separate programs and to have separate policies governing these programs. We have also developed a number of new interactive relationships to promote efficient coordination and management while protecting the integrity of NASA programs. We have just finalized a renegotiated Shuttle pricing agreement with the Department of Defense. This new agreement will provide NASA with increased reimbursements of approximately $1 billion during the next 5 years over the amount that the agency would have received under the previous policy agreed to in 1977. This revised policy will raise the Shuttle launch cost to DOD, and for launches in fiscal year 1986 through fiscal year 1988, this results in an increase of almost 150 percent above the previously set launch price.

I would be remiss, Mr. Chairman, if I did not conclude this portion of my testimony by talking about the future. The President's space policy recognizes the importance of developing new concepts which provide a strong vision of the future, not only for our space program, but for the Nation as a whole. In his space policy, the President requires NASA to continue to explore the requirements, operational concepts, and technology associated with permanent space facilities. The Space Shuttle makes it easier to establish larger permanent facilities in space. NASA's proposed fiscal year 1984 budget includes modest funding for definition and planning efforts which will allow us to understand, in greater detail, how such permanent facilities might be developed and maintained in Earth orbit. These studies will provide a basis for considering possible future proposals to establish a permanent manned station in Earth orbit.

Mr. Chairman, I have discussed some of the important highlights. I would be happy to answer any questions.

Senator GORTON. Could I get your comment on the Washington Post story, to which I referred in my opening statement? Do we look forward to serious competition in fields in which NASA has been preeminent from the Japanese in the foreseeable future?

Mr. BEGGS. The Japanese are very active and have made a national commitment both in the aeronautics and space arenas; and, they have increased their budget in both those areas significantly over the past 4 or 5 years.

I would expect that in the commercial aspects of space, which is where they generally concentrate their activities, that we will see more of them. We are beginning to run into them on the international market from time to time, and in the commercial side. They are interested, of course, in the communications satellite business. They are interested in the Earth observation business, the Landsat kind of business. They are very active in development of the technology for the 30/20 gigahertz range, which will be the new arena for satellite communications. They have, over the past several years, been developing a space launch capability, expendable launch capability, in the Delta vehicle class. That technology, incidentally, has come from us. But they are pushing ahead on that.

In the aeronautical field, they are active both in the propulsion side and in the airframe side. They have made a number of agreements with the Europeans in the propulsion area; particularly with Rolls Royce for development of pieces and parts of jet engines. And, they have been in a cooperative program with U.S. manufacturers and European manufacturers for construction of pieces of primary structure. It is obvious from that activity that they are proceeding as they usually do in a very well-staged, planned activity to build a capability both in the technology and the manufacturing side so that they can enter those markets on a systems basis. I would expect to see them entering that market perhaps toward the end of this decade.

They, of course, have also made a national commitment to the supporting technologies of computers which are a very important supporting technology for space and aeronautical activities, and are very active as well, as we all know, in the electronics side, which is also a supporting technology. So yes, we will see more of them. They look on the experience we have had in aeronautics and space as an activity that has been very beneficial to the United States. It has created jobs; it has resulted in a very substantial addition to our balance of trade. As a matter of fact, aerospace exports are, in any given year, the largest industrial contributor to the balance of trade. The Japanese have drawn on our lessons.

I might say that the Europeans are equally active, and they have been increasing their budgets, if anything, faster than the Japanese in these same areas.

Senator GORTON. Thank you. NASA says a manned space station can be launched by 1991 at a cost of $4 to $6 billion. Dr. Keyworth, on the other hand, has stated that a manned space station might cost as much as $20 billion. Can you account for the difference?

Mr. BEGGS. I have not specifically discussed with Dr. Keyworth the $20 billion estimate he made, but I would generally comment as follows: Space stations are the kind of development that you can buy by the yard. That is to say, you can buy them modularly and you can start with a capability that could be modest in size, and that, indeed, is the $4 to $6 billion figure. I think you can get a very adequate beginning capability at that price. Or you can start somewhat larger. What Dr. Keyworth may have been referring to is an ultimate capability of adding to a beginning $4 to $6 billion investment and building to where you had a very substantial activity, not only in doing the things that we envision doing, which are Earth observation, and perhaps some science and materials processing, but including quite a substantial industrial activity as well as a much more substantial scientific activity.

I might add, Mr. Chairman, that we have had a fairly substantial interest in a space station development, internationally and on the part of the industrial sector, in joining in a cooperative program. Both the Europeans and the Japanese are interested in joining with us in a cooperative program. Obviously, they are interested in the fallout of technology as well as in exploiting the space station itself for industrial and commercial exploitation.

The industrial side is equally interested in perhaps having industrial modules that they could rent or lease to various and sundry individuals who are interested in commercial development in orbit. So, there is quite a lot of activity, and the program could grow substantially from an initial capability to the kind of figure that Dr. Keyworth envisioned. However, I would expect that an expenditure of that type is something that you would look at over maybe 20 years, rather than the 10 years you cited as being what we project for an initial operating capability.

Senator GORTON. NASA has a memorandum of understanding to study with Fairchild Space & Electronics the potential of the small space platform, the Leasecraft, to be placed in orbit and available to commercial customers by 1986. What is the status of that study?

Mr. BEGGS. We have proceeded to the point really of signing an agreement with them. We have not fleshed out the study to the point where we know specifically what will be involved on NASA's part. The Fairchild Co. is, on its own, interested in developing this capability as an adjunct to their other commercial activities in space with the idea of providing a utilities platform to the industry.

We, on our part, would be expected to coordinate with them so as to make it fully shuttle compatible. I would expect that in the future it would be handled much like the upper stages are handled with the shuttle. That is, some customers would ask NASA to manage it for them; other customers who are more sophisticated could negotiate and contract directly with Fairchild, but we would necessarily be in the loop in the activity of mating it with the shuttle and insuring that it got into proper orbit.

Senator GORTON. Is it likely that the cost to NASA of this project will be substantial?

Mr. BEGGS. We might be asked to provide transportation in the initial stages of development just as we are asked in the various joint endeavor agreements. We will provide transportation during the experimental checkout of the system.

Senator GORTON. Is it a step toward a larger manned space station, or is it off on a tangent?

Mr. BEGGS. I envision a whole range of activities in this regard, Mr. Chairman, from the rather modest platform that Fairchild has in mind to service single payloads, to perhaps more complex platforms which would support clusters of instruments or clusters of experiments or clusters of industrial activities, which could be revisited by the Shuttle from time to time, or platforms could fly in close proximity to a manned space station so that they could be man-tended.

The addition of man-tending to a system adds an enormous capability because you can replace pieces and parts which fail in orbit. You can service finished products, and resupply with feedstock or with new raw materials. In short, the addition of man adds a whole new dimension to the unmanned platforms. But the unmanned platforms are necessary when you do not want man in close proximity to your instruments while they are operating. So the idea of having platforms flying close to a space station with the ability of the man in the space station to tend them, to observe them and to monitor them, is a very substantial additional capability.

Senator GORTON. Assuming we decide to make a commitment to such a space station project, are you convinced that we can assure a balanced level of effort among other programs which would not, in all probability, share the same degree of public interest?

Mr. BEGGS. Let me try to answer that question in several ways. As the Shuttle starts to fly at a higher flight rate—we are planning to fly 5 times this year, and I believe even with the delay we have experienced, we have a good chance of getting off the five flights. Then, we are going to fly 9 times next year and then build up the rate eventually to perhaps 20 to 25 in the late 1980's.

The reimbursements from those Shuttle flights will start building up. As a matter of fact, this year our total reimbursements, not all from Shuttle but reimbursements for all the various services we supply, will amount to on the order of $1 billion. By the mid-1980's it will probably be up over $2 billion. So at some point, the Shuttle operations will start to be supported very substantially by the reimbursements. That will make money available, assuming just a constant level of appropriated funding in our program, both to do the development of a space station, assuming that we move ahead with that, and the other new initiatives that we have in mind to continue our planetary exploration, our science, our aeronautics and other activities that we discussed earlier.

The other activity that we must complete, of course, is the full operational development of the Shuttle, and I believe that we should have that in hand by the mid-1980's. We have experienced some problems with the Shuttle main engines, which I am sure we will discuss this morning, which will require some further work. But we should have that pretty well in hand, and that budget, in turn, should start to come down in the 1985–1986 time period. So, assuming a level appropriation, there should be funds becoming available from these projects to maintain the balance in the total program.

We have tried, in the last two budgets that we have sent to the Congress, to increase the funding for the research and development side of NASA; the space science and exploration activities of the agency have been increased very substantially over the past two budget cycles and are further increased in the 1984 submission. It is our intention to continue that emphasis and to continue to expand. With all that, there should be enough money to move forward with the activity in the manned side for the more permanent presence.

Senator GORTON. Thank you, Mr. Beggs. I am going to have to leave at this point. I have numerous additional questions which I will submit to you in writing to the extent that they are not covered by Senator Trible or by Senator Heflin. But I thank you. Senator Trible.

Senator TRIBLE [presiding]. Thank you, Mr. Chairman. Gentlemen, laminar flow control which supports air craft design and configuration, was eliminated in the fiscal year 1984 budget, as was the advance transportation operating system [ATOPS], a program designed, of course, to improve traffic safety and fuel efficiency.

These programs, to my mind, offer great promise. I understand the funding for these programs was blocked by OMB. My questions are threefold about each program. Tell us something, if you will, about the history of these programs and what has been achieved to date. Second, the promise of these programs; and third, what funding would be necessary in the next fiscal year to continue these activities.

Mr. BEGGS. Senator Trible, let me start by relieving the OMB of some of the responsibility. We really ended up by racking up the NASA priorities for the aeronautics research within about the $300 million level, which was about the level we agreed with the OMB that we should have for aeronautics in 1984. It was our priority list that caused this particular activity to fall off the bottom. It was not, strictly speaking, an OMB responsibility to throw this out. That is, they have nothing against laminar flow control or any of the other activities which were eliminated from the budget. They simply laid it on us to make priorities.

As I said in my statement, we placed the numerical aerodynamical simulation activity at a very high priority; we wanted to get that started, and that caused some of the other activities to be pushed down in priority.

Laminar flow control has been a research program in aeronautics for a number of years. It probably goes back 20 years in the NASA program. It is, of course, the age-old technical battle to reduce drag of a flying machine and thus, increase its efficiency of operation. And it has made some very significant technological contributions to the industry.

There are a number of techniques now in use by the industry to work on the boundary layer that exists around both the airfoils and the fuselage of aircraft, which is generally turbulent and induces drag. Boundary layer control devices are installed in the machines in such a way as to make them more efficient. There are a number of other possibilities in the technology which look promising in improving flow around airfoils and other parts of the aircraft, and we would like to pursue those and we are, within the research and technology base program. We have about a $2.5 million ongoing activity to work on those promising techniques.

Now, when you get to the point where you have a technique that you think will work, you want to fly it, you want to put it on an experimental airplane and test it out because while you can do a great deal in simulation and wind tunnels, the proof of the pudding is in flight testing to see whether it will work. It is that part of the program that we have temporarily delayed with this budget. We will not have the flight research in laminar flow control that we have had in previous years.

However, as we develop the new techniques we will proceed to do that kind of work in future years, and will budget for them. But we felt that this was one that we could, if you will, put back in the laboratory for a short period of time and pick it up later.

Senator TRIBLE. So that is an answer to my first question. The second was about the advanced transportation operating system.

Mr. BEGGS. The terminal configured vehicle [TCV] has been operative for a number of years at Langley and we feel it has been a successful program. The new series of transports, the 767's, the 757's, incorporate some of the cockpit displays and cockpit techniques that were developed out of the TCV over the past several years. The vehicle will continue to be operational in the 1984 time period. We are not putting in money to advance the art further at this time.

There is a very close cooperation between NASA and the FAA since in order to move forward further with TCV-type techniques, we need to coordinate with the FAA in the configuration of the national control system that they use. We do run a number of tests with the FAA and we will continue to run tests with them flying in and out of their experimental facility in Atlantic City, and using some of the airports in the vicinity of Langley. There is about $5 million included in the base program for these activities in 1984.

Senator TRIBLE. What level of funding would be necessary to operate these two programs?

Mr. BEGGS. I would like to give some thought to that. In total, I think we had another $10 million to $15 million in those programs when we had discussed them with the OMB originally. If I may, sir, I would like to supply you an answer for that.

[The following information was subsequently received for the record:]

The Fiscal Year 1984 funding necessary to conduct the Laminar flow control program and the advanced transport operating system program as planned would be $3.3 million and $8.7 million, respectively, for a combined total of $12 million.

Senator TRIBLE. Please. I have a host of questions, but I am going to turn things over to my distinguished colleague from Alabama for his questions at this point.

Senator HEFLIN. Thank you.

Mr. Beggs, in your statement you say that "There is no doubt in my mind that the investment this Nation has made in the Space Shuttle will pay off handsomely. We know enough about the system so that I can make this statement with great confidence." I think it would be very helpful to this committee and to the public to focus on that conclusion. We would all agree. It would be helpful if you would spend a minute or two elaborating on the ways you think the investment has been a good one and the way you think the investment will continue to be a good one.

Mr. BEGGS. With the Shuttle, we have a very versatile transportation system that I believe can operate in any number of ways to expand our capabilities in space, not only for NASA's science and technology work but for the commercial sector in expanding their horizons in space, and, of course, in support of our very important national security objectives.

With the Shuttle, we cannot only deliver satellites and spacecraft into low Earth orbit, but now we will be able to deliver them all the way up to the geosynchronous orbit or launch them for the exploration of the planets because we are adding, with the assistance of the Congress last year, the Centaur high-energy upper stage to the system shuttle right now.

We can also revisit satellites and spacecraft which are in orbit, thereby enabling us to service them, repair them, or if necessary, bring them back, to reload them in the Shuttle to bring them home. Thus, there is a potential for very, very large financial benefits that will accrue from the system because many of the spacecraft we are talking about are spacecraft that cost upwards of hundreds of millions of dollars. As a matter of fact, some of these spacecraft are in the high hundreds of millions of dollars. So there are substantial benefits from our ability to service in orbit or return them to Earth for repair.

We also have the capability, as I stated in answer to the question that the chairman directed to me on permanent facilities, of locating in orbit permanent facilities which can either be manned, or in some cases unmanned, but are man-tended. Those permanent facilities should enable us to learn a great deal more about both the industrialization or commercialization of space and to expand our activities in science by significant degrees.

We will, as we complete the operational development of the system, have a capability of carrying upward of 65,000 pounds into low Earth orbit at low inclinations. The Shuttle system, as we know, will be operational both from an east coast launch site, at the Kennedy Space Center [KSC], and from a west coast launch site out of the Vandenberg AFB facility for polar orbits. Thus, we can put both commercial, scientific and military satellites in any of the desired orbits required. We can carry payloads higher than the current series of expendables are capable of launching and with greater versatility.

We are just beginning to learn some of the things we can do with this machine. The first five flights gave the astronauts a feeling that they had a very, very capable system indeed. They all came back with a feeling that we had much yet to learn. The system as it developed would become much more capable, and, in fact, I think that we will see developments in the use of the system that we do not yet envision because it is so versatile.

Senator **Heflin**. Thank you.

I understand that NASA is reviewing the merits of moving the solid rocket booster processing facilities. When do you anticipate making the decision on this?

Mr. **Beggs**. We are examining both of the options that we laid down on paper. First, I should say we need to get this activity out of the vertical assembly building at Kennedy. As we build up the flight rate, the VAB will be fully used for the processing of the Shuttle system itself; and, therefore, we need the space that we were using for the processing of the solid rocket boosters to directly support the work on the Shuttle system itself.

So, when the conclusion was made that we had to get it out of the VAB, we started looking for a possible other site.

There are several possibilities. One is some unoccupied or partially occupied facilities on the Air Force side of Cape Canaveral; another is a new facility located on or near KSC; and the other is a couple of buildings which are partially occupied at the Marshall Space Flight Center. We need to look at those options more closely to see which is the best way to proceed both from the financial and operational point of view, and we are doing that right now. I expect to revisit this in the coming 10 days or so and make a decision as to which way we go.

Senator HEFLIN. In the past year the Commerce Committee and the Congress have supported the production of a fifth orbiter. Last year both NASA and DOD supported the requirement for a fifth orbiter. This year, after review of Shuttle demand forecasts, the OMB and NASA agreed that a fifth orbiter is not justified.

What specifically has changed in your demand forecasts, and is your judgment mainly based on Government use of the Shuttle? What about commercial use?

Mr. BEGGS. Our previous position on this was a projection of the flight rate which would be required to meet a demand model. We had several studies done as to the potential market demand for the Shuttle services over the next 10 years. We were projecting the need for the fifth Shuttle on the basis of a demand model which was in the center of the various demand studies that had been done. That is, it wasn't on the low end and it wasn't on the high end. When you look at that, the demand could have been met with the four orbiter fleet. However, the problem was that if you ran into an accident or had to lay up an orbiter for a period of time for modification, then you would run short of meeting the demand with the three remaining orbiters. Therefore, the fifth one was considered as being desirable in the mid- to late-1980's.

When we took a look at the demand last year, as it was developing in the manifest that we had for the Shuttle last year, we found that the market was really developing along the lower end of that demand forecast. I should add that this is not untypical of a new market; that is, the tendency is for the market to hold back in the early stages until they realize the advantages of a new system, and then the market expands. So, it is not disturbing to me that we are running along the lower side of that demand forecast, but it does mean that we cannot justify the need for a fifth orbiter in the near time period. In our discussions with the OMB on this issue, we said that if we have the opportunity to either fill in if we had an accident on one of the four orbiters we have, or potentially to build a fifth orbiter should the demand build up, we thought that we could satisfactorily meet our requirements.

The OMB agreed with that and we have in the budget this year the beginning of about a $400 million investment; that is, $100 million in 1984, which would be $400 million in runout to buy the structural parts of a fifth system, which could be used either to repair one of the orbiters which were laid up or, as the President stated when he approved this decision, in the event that the more optimistic estimates of Shuttle demand prove true, we can then assemble a fifth orbiter. I believe that this option, while it is a compromise to the position that we originally took here, is a sound decision. It preserves our capability to assemble it for another year or so and, I think, is a satisfactory answer to the problem.

Senator HEFLIN. NASA, of course, is among the most, if not the most preeminent of our national research and development agencies. As a research and development agency, however, there is some question concerning the future operation of the Shuttle.

I believe last year the committee recognized the huge task associated with Shuttle operations. In our committee report we suggested the annual budgetary decision process that NASA faces may not be conductive to management trying to seek the most economical operational system.

Accordingly, the committee suggested that NASA seek external review of its Shuttle operations, cost and pricing policies. Has NASA requested such a study from financial management experts as indicated in the committee report?

Mr. BEGGS. We have an ongoing study with the National Academy of Public Administration which is looking at the commercial uses and the industrial uses of Shuttle. That committee does include individuals with a financial background. I think they will report to us in late spring of this year and we will have what I think is a very good study. At least from the meetings we have had with them in their deliberations, it looks like they are viewing their charter broadly, which is what we want them to do. It will be a good study in light of the interest that the committee has in looking broadly at this problem.

In addition, an independent group of financial experts reviewed the recently established STS pricing policy for fiscal year 1986 through fiscal year 1988 prior to its implementation.

The question of finances on the use of the Shuttle, turns out to be a fairly complex issue. We have projections or learning curves, on the various parts of the system from an operational point of view. I might add that we are doing pretty well against those projections. The time that it is taking to turn the Shuttle around to refurbish and get it ready for the next launch is coming down very well, and the production of the expendable parts of the Shuttle, the external tanks and the solid rocket boosters, is doing very well against those learning curves. As a matter of fact, in some cases they are exceeding the estimates we have made.

As you know, Judge Heflin, originally the Shuttle pricing and financing was based on a mission model. We priced this just as you would a new commercial production system such as a commercial transport, aircraft transport or even a new model of an automobile. When we looked at that a couple of years ago, we felt that we had been overly optimistic, particularly in the near term in that mission model. Therefore, we cut it back and that necessarily changed the financial aspects of the early years on the Shuttle.

So, we felt that we had to reprice the Shuttle significantly in the near term, and, indeed, we have. We did not have the option of repricing it in the first 3 years because those prices had already been committed to our commercial and foreign customers, but we could reprice for the out years, and we did. From 1986, 1987, 1988, we repriced significantly. We did that pricing with an eye to trying to recover the additive costs of the system over the near term. My belief is, that as we continue to work down the learning curve, that we will eventually reach a point where we can break even at somewhere close to those prices, or maybe a little bit higher, but roughly on those price projections. Perhaps out in 1988 or 1989, as we approach the 1990's, if we could do that, and I believe we can, then we would have a very viable commercial system. That is, we would have a system which could operate maybe a little better than break-even, carrying the manifest that we see it carrying in the late eighties.

As you know, we are looking at perhaps 20 to 30 flights a year in that time period. If we can build up a flight rate to an even higher rate, that would make the finances look even better because the system is very, very sensitive to flight rate. So, once you put the facilities in place and once you have the manpower in place to do the basic job, you don't have to add very much to increase the flight rate. Therefore, if we could have a flight rate of 35 or 40 in the early 1990's, this system would look very good as a potential commercial possibility.

Senator HEFLIN. What is NASA's plan for the technology development of propulsion capability and propulsion system design, and do you foresee a plan to initiate test stand work in support of future launch vehicle engine system requirements?

Mr. BEGGS. That comes in two parts. One of them has to do with the Space Shuttle main engines, which are cryogenic machines. What we have now is a very adequate engine at the 100-percent rated level. The engines we flew on Columbia worked very, very well at the rated power level, and we think that once we get complete control of our production and test processes, that we will have an engine that can be operated reliably and repeatedly at the 100-percent rated power level.

However, where we have run into difficulties and need additional research work is when we try to run those engines up to 109 percent of rated power. We have had significant problems develop in the engines, probably because we have vibratory loads and maybe some things we don't understand that are causing components of the engine to fail too early. We need to do research on that. We are initiating a research program and we probably will be coming back to the committee asking for additional work in research on the SSME's. We may possibly be asking for some reprograming for that in fiscal year 1983, but I am still reviewing that.

We do have, in the space research and technology line, about a $15 million budget which includes our work on the basic technology of engines but we do have a problem and we are going to have to work hard, I believe, over the next 3 or 4 years to get that problem completely in hand, because we would like to be able to operate those engines at least at the 109-percent level. If we could get that up even higher, it would add very significantly to the capability of the Shuttle both to carry loads and to go into different and desirable orbits.

With regard to the solid rocket booster, we are doing quite a lot of additional research and technology development on that in the lightweight case area using graphite apoxy filament wound technology to get a lighter weight case. We are also working to improve the propellant on the solid rocket booster to get additional capability out of the SRB. I think that is a little bit easier technology program in that we understand that a good deal better than we do some of the phenomena we are running into at the higher power levels on the SSME. But, we will be working to improve the SRB's for another 2 or 3 years.

Senator HEFLIN. NASA has requested $5.2 million for a teleoperator maneuvering system, but OMB did not allow any money for that. What effect will this decision have?

Mr. BEGGS. We are continuing to work the teleoperator maneuvering system as a research and technology program. We think that one has great promise. The advance definition fell out of the budget this year for two reasons: One, it didn't fit within the budget levels, and two, it was felt, I think, that we were not quite ready to initiate a development program in fiscal year 1984. But, we think it has great promise and will continue to keep it on our agenda and pursue the concept for development in the future.

Senator HEFLIN. Sources tell me that the McDonnell Douglas NASA joint agreement in material processing seems to be working out well. I understand that the Shuttle experiments have been very promising. If these electrophoresis experiments prove to be as successful as many people now expect, could this be the opening wedge in the development one day of a multimillion-dollar industry, maybe even $1 billion industry? Are the prospects for this in the long range good?

Mr. BEGGS. I have to control my enthusiasm for this one because it does look very, very promising. Indeed, it gives great promise of being the first of what will be a series of major commercial activities drawing on the technology of the Shuttle. The results of the first experiment we ran on the McDonnell Douglas equipment, which is, in effect, a piece of commercial apparatus, were very good. They exceeded the engineer's predictions by a substantial amount, both with regard to the purity of the product they produced and with regard to the quantity of the product from the device.

What McDonnell Douglas was doing, was running some test samples. The next time we fly it, it is my understanding that they plan to try to obtain commercial quantities of a specific pharmaceutical. I am not privy to what they are planning to fly because it is a private agreement between McDonnell Douglas and Johnson & Johnson.

But they have told us that they are very optimistic, so optimistic that they are ready to proceed with a test of a commercial pharmaceutical, and to me that is extraordinary at this stage. If they get what they are looking for, we may, indeed, have a new industry because what you can get out of this continuous flow electrophoresis device is very high purity and very high quantities of materials which are available only in very, very small quantities here on Earth. While electrophoresis does work on Earth, it works very poorly because of the effects of gravity. In the zero-g of space, it was predicted, and, indeed, it seems true, that it will work much better.

If it does, you are looking at a multimillion-dollar kind of industry, and it will place an immediate demand on permanent facilities or some kind of platforms in space to service this equipment for extended periods of time.

Senator HEFLIN. NASA requested $30.3 million for material processing, but only received $21.6 million from OMB. Isn't even $30.3 million a small amount for basic research in this area, particularly as it stands to become one of America's frontier industries?

Second, what is the status of the Germans' effort in this area?

Mr. BEGGS. We have several activities going on right now in addition to the electrophoresis activity we have just discussed. These activities relate to crystal growth as well as examining various and sundry metal and other types of materials that could be produced in the environment of zero-g. I think the amount of money we are spending at this time is about right. I think the number of ideas we have had to date—at least my review of them—is that we are pursuing the most promising of those materials processing proposals that we have had.

The Germans and the Soviets are very active in materials processing. I am going to let Dr. Mark add to my remarks because he has some insight into the German program that I do not have. The Germans have a very active program, as do some of the other European countries, and they intend to fly materials processing experiments in the Spacelab when it is flown. That activity has been in their budget for a number of years.

As I mentioned, the Soviet Union has been conducting a number of materials processing experiments which we are not privy to, but which we have heard bits and pieces about in their space station activities over the past 3, 4, or 5 years. Apparently, they have conducted a lot of experiments, the results of which are mostly unknown, except for what they have told us in bits and pieces in the exchanges. We do have U.S. experiments in the Spacelab which will fly later this year—at least I hope it will fly late this year or early next. Those experiments represent an investment of about $4 million, which is the 1984 investment in them, representing an investment of significant sums of money over the past several years.

Hans?

Dr. MARK. No; I do not think I have anything to add.

Senator HEFLIN. Well, if we move forward and have as much success as we have had to the present date, suppose that this next effort does prove highly successful and indicate that there is the potential of success, do we have any plans which might accelerate the research and development and which would call for substantial increases in this area, and an acceleration of research activity?

Mr. BEGGS. Senator Heflin, I would very definitely recommend an increase if in our Spacelab experiments we get some results which indicate that a larger investment would be cost effective.

There has been a lot of stories and literature on what we might get from materials processing in space. To date, we have done a few experiments. We, of course, have had the experiments on the Skylab which, incidentally, were the ones that gave us insight into this electrophoresis arena. And, I might add that when the Skylab indicated that electrophoresis was a real possibility in space, the McDonnell Douglas people and Johnson & Johnson immediately moved out to make a very large private investment. I do not know how much they put into that, but my guess is that it has been upwards of $100 million so far. So, the minute you come up with something that has a potential, you do attract private venture capital. If we start to see something from the early experiments, I would certainly recommend that we put additional money into that to carry it to the point where we can attract the venture capital out of the private sector.

I do think that once you have demonstrated commercial practicability though, you should pass it over to the private sector and let them develop it, because it is necessary to have someone who is oriented to the market to take over that activity very quickly, in order that they can exploit it more fully and in a hurry.

This has become a small world, particularly with regards to new ideas and we must, I believe, exploit quickly those activities that are developed under our research program because if we do not, someone abroad will. But, I think that we have got enough money in the $21 million in 1984; that is about the level we have been running for the last year or so.

Senator HEFLIN. Was that decision made after OMB suggested it, or was it made when it was originally proposed?

Mr. BEGGS. I have to say that most of the decisions on the budget this year were agreed to jointly between the OMB and the agency. We were not cut back arbitrarily in any of these areas.

Now obviously, in a lot of the areas we would like to have a little more money, but I think we were satisfied at the end of that budget exercise that the requirements that we had were satisfied, at least to the degree that we felt was essential.

Senator HEFLIN. I have to be at another place and I am going to have to submit other questions. I would like to go into communications and aeronautics as well as some other matters, but I will submit them in writing.

Senator TRIBLE. Thank you, Senator Heflin. Gentlemen, let's shift our attention to aeronautics. In our opening colloquy we discussed the ATOPS program and laminar flow control. What about the advanced turboprop program?

Mr. BEGGS. It is a promising technique, and I think that we have got to continue the research work in it. The activities that we have had over the past several years have been directed toward reaching the point where perhaps we would eventually see the advanced turboprop flying in either an experimental vehicle or a developmental vehicle.

We know we have excited some interest in the commercial world on this technology, and we are flying a small scale experimental version on an existing experimental aircraft out at the Dryden Flight Research Facility Test Center.

It was felt in the 1984 budget that this one could be postponed, and so it was. As I said, we pretty much came to an agreement with the OMB on a series of priorities, and this one, unfortunately, did not make the list. We had asked for $8.7 million to continue our flight experiments on that in 1984, and I think that would have been an adequate amount of money.

We have about $2 million in the R&T base to continue the work in the wind tunnels and laboratories on the technology in 1984. In the coming year I think we will be in a better position to judge what the next step should be in terms of propeller technology development.

Senator TRIBLE. Your testimony is that in order to continue pace with that program, it requires $9 million?

Mr. BEGGS. No. If we were to have proceeded through 1984 in moving forward on a flight demonstration, it would require about $8.7 million in fiscal year 1984.

Senator TRIBLE. And what is the funding for that program?

Mr. BEGGS. About $2 million in the R&T base for 1984. There is about $16 million in the 1983 budget.

Senator Trible. Again, if you will, I would like to see the levels of funding projected for these programs in the next fiscal year absent the joint decision of NASA and OMB for each of these programs. Budget documents suggest that the ATOPS program proposal was to be $8 million in the next fiscal year and laminar flow program $3.3. million. But if you would submit the precise figures to the committee, that would be helpful.

Mr. Beggs. All right. Yes, sir, we will. Those numbers are approximately correct. We will get the exact numbers.

[The following information was subsequently received for the record:]

NASA's fiscal year 1984 OMB budget request for these programs was as follows:

	Fiscal year 1984 (millions)
Laminar flow control	$3.3
Advanced transport operating systems	8.7

Senator Trible. Moving on, sir, NASA and DOD are involved in two joint aeronautic projects; one, a NASA-Air Force project on advance fighter technology integration of the F-16 aircraft, and second, a NASA-Defense advance research project agency project, to develop the technology base for the X-wing rotor concept. How are the responsibilities and costs and results shared in those two projects?

Mr. Beggs. The basic philosophy of most of these programs which are joint is that the DOD generally puts up the money for the hardware, we put up the money for the test and integration of the facilities. Now generally, that is the way it is divided in these areas. We have, over the last 70 years, flown experimental airplanes. Many of them have been joint programs with the Department of Defense or one of its agencies. Most of the current programs are shared with either the Army or the Air Force.

The relationship with the Army on the rotorcraft work has been very productive, both for NASA and for the Army. The Army has a group of research personnel stationed at Ames, and they work as though they were NASA employees; that is, they work hand in glove with us. The results of that work on rotorcraft have been incorporated in our experimental programs and have been shared with the industry and, thus, show up in commercial products.

The X-wing is another along that general series of joint activities and it shows great promise. We will provide funds, as I said, for the tests and the pursuit of the research in it, and they will fund hardware and for some research on their own. We are budgeted through 1987 on that program at about $30 million; $6 million in 1984.

The tilt rotor is a program which could result in a truly joint aircraft system. I guess I will be very surprised if it ends up that way, but the Navy, the Marine Corps and the Army have a requirement for this kind of vehicle. As a matter of fact, the Air Force might even buy a few of them. But, the three I mentioned are the prime customers. They have been actively discussing a joint development program building on the technology we developed in NASA on the tilt-rotor concept, the XV-15, which as you know, was incorporated into an experimental aircraft, flew, and is still flying.

We have about $2 million to continue our research work. If the military goes forward with a development program on that, we would continue to participate in the sense that we would help them with the wind tunnel testing and research that they needed through the development period, and we would like to fly their developmental airplanes in order to learn from them and to advance the technology.

The military has been very forthcoming in terms of providing NASA with the developmental airplanes that come out of these programs. We fly a number of aircraft which were developed by either the Air Force, the Army or the Navy. At Dryden, we modify them, we instrument them, and we learn a great deal about the flight of those aircraft which turns up in our research, not only turns up in our research, but is then published and appears generally throughout the industry. So it has been a very valuable collaboration between NASA and the military services.

Senator TRIBLE. Good, thank you very much. Tell me, does NASA consider its new aeronautical program, the numerical aerodynamic simulation, a candidate for private industry financial participation?

Mr. BEGGS. Yes, we did. I am going to let Dr. Mark discuss this more fully, but yes, we did. Hans, do you want to talk to that point?

Dr. MARK. I guess your question is specifically financing by private industry. We did not really have a plan to put private financing in at the beginning, but there is strong reason to believe that if the mainframe computer that comes out of this is something that looks attractive to the commercial companies, that later on in the program we may very well embark on a jointly financed activity. Right now, we do not have any private money.

Mr. BEGGS. We did take a look, I guess about a year or so ago, at the possibility of the industry coming in and either sharing in this cost or becoming a partner with us, if you will, in the development of this capability. We were unable to elicit any great interest on the part of the aerospace industry to move in on that.

First of all, the technology we are developing is far enough out that it is hard to see near-term results. It is, in short, the kind of thing that the Government ought to do; that is, it is fundamental and basic work. Where the risk is so high and the payoff is so distant, it is hard to get interest on the part of private industry in participating in any meaningful financial way. Unfortunately, in recent years the time horizon that the industry has to look at for payback on their R&D investments has shortened, which necessarily puts an even greater burden on the R&D activities of the Government to insure that we do make the investments in the longer term requirements so that we have them when they are needed.

The NAS is, we believe, something that is going to pay off very, very big, probably toward the latter part of this decade. We will be developing this over the next 3 to 5 years, and as Dr. Mark has stated, we will be pushing the technology of the computer art during that period which will have a fallout into the computer science area in a commercial way. But, more importantly than that, the techniques that we develop here in our ability to do, in a mathematical way, fluid dynamics should have a fallout broadly throughout the industry. Anyone who uses fluid systems of any type will have a reason to use the kind of techniques that come out of this, and that is, broadly through the industry. So we expect a big payoff in the late 1980's and 1990's from a system such as this.

Our foreign competitors understand that. The Japanese, for example, have a study going on right now for a facility.

Senator **Trible**. How does our effort compare with the Japanese?

Mr. **Beggs**. Bigger and better.

Dr. **Mark**. Senator Trible, may I add one other point to what Mr. Beggs has said, which I think is important in terms of your first question with respect to the participation of the industry in one of these things.

The Government has traditionally funded advanced computers such as this one because we, the Government, have certain unique requirements. Let me give you a couple of examples.

The IBM computer systems that were the first large mainframes that were developed in the late 1940's and the early 1950's were put together to do the battle management of our air defense system. Those computers, after they had been developed for that purpose, became the first generation of mainframe computers that were commercialized.

In the 1960's, Control Data Corp. [CDC] developed three computers, the 6400, the 6600 and the 7600, because the computers were required for nuclear weapons design. In each case the computer was developed by the Government because of a unique technical requirement and then commercialized afterward.

What we are doing here, sir, is to go down a well-trodden path which we really know how to take advantage of. And, I thoroughly and strongly support the statements that Mr. Beggs has made with respect to the payoff, because we have made this trip through the woods before, sir, successfully.

Senator **Trible**. I appreciate that additional comment, Doctor. Let me ask you this, wrapping up these questions, if I may, in the field of aeronautics.

The aeronautics budget for fiscal year 1984 contains a number of programs with primary military applications. Well, there seems to be perhaps less push in programs that have primarily civil application. What do you think the programing in the aeronautics budget—how does it fulfill the responsibilities in aeronautics research and technology, as announced by the President's Science Adviser last November?

Mr. **Beggs**. That policy study, as you know, Senator Trible, said that we should do research in support of both civil and military, and we should do demonstrations in support of the military. It is true that the systems technology items include things which will lead to military kinds of systems. That is, they are directed toward military applications. However, the R&T base line, which is by far the larger part of the budget, supports both, and we have found—and the GAO recently has found as well in their review—that about 95 percent of the research and technology that we do in the aeronautical research and technology program is applicable to both.

I have rather direct experience with this in my most recent past because when I was with General Dynamics (GD) my responsibilities were, of course, both the civil and the military aeronautics that GD undertakes which produced both. But to give you one example of this, one of the wings that was developed in the R&T base for supersonic transport application happened to be a wing that we felt would look pretty good on a fighter plane. We put that wing on a fighter plane and, indeed, it made a better fighter plane.

That was an example of civil technology contributing to a military application. I can give you dozens of cases where the military technology contributed to civil programs, going all the way back to the original jet transport; the 707 that Boeing developed that came out of work that both NASA and the military had done on tankers.

The activities in the R&T base, I think, are well constructed to support the industry broadly, whether they be in the civil arena, such as general aviation and civil transports or the helicopter arena, servicing both military and civil, or the purely military arena. And we are satisfied—at least, I am satisfied that what we have in that program is a very well-drawn research and technology activity that will maintain the preeminence this country has enjoyed in aeronautics for the last 25 years.

We continue to be able to produce superior transports; the 757/767 that Boeing just introduced are superior to any transport in the world, and they are superior primarily because they contain the superior technology developed from our program, both in the propulsion area and in the airframe area.

The general aviation craft which we produce in this country outsell any general aviation craft produced anywhere else in the world, and all of them contain some NASA aeronautics technology. Some of them contain a very great deal, and they all go through our wind tunnels. And all of the military aircraft that currently fly contain a lot of NASA technology. Therefore, I think that the program has served the Nation well for the last 20 years, and I think that the program we are presenting to this committee for 1984 will serve as well in the next decade.

[The statement follows:]

STATEMENT OF HON. JAMES M. BEGGS, ADMINISTRATOR, NASA

Mr. Chairman and members of the committee, it is a pleasure for me to appear before this distinguished Committee to present President Reagan's budget request for NASA for Fiscal Year 1984. The total request is $7.1 billion, of which $5.7 billion is for Research and Development, $150 million for Construction of Facilities, and $1.25 billion for Research and Program Management. A chart summarizing NASA's Fiscal Year 1984 request is appended to this statement.

I am particularly proud to be at NASA in 1983 to celebrate its 25th Anniversary. During the 25 years since the United States entered the Space Age, our space program has grown from the 14 kg Explorer, launched in January 1958, to a truly reusable Space Transportation System.

With your permission, Mr. Chairman, I would like to spend a few minutes discussing some of the acheivements of the past year—achievements which have been very significant, indeed, and which would not have been possible without the strong and continued support of the Congress. In 1982, the Space Shuttle Orbiter Columbia made three successful orbital flights and during each flight, significant progress was made in understanding the operational features of the Shuttle system. This initial phase of the STS flight program culminated with the first operational flight in November 1982, during which two commercial communications satellites were launched. There is no doubt in my mind, Mr. Chairman, that the investment this Nation has made in the Space Shuttle will pay off handsomely. We now know enough about the system so that I can make this statement with great confidence.

As you know, a new earth observation satellite, Landsat 4, was placed in earth orbit in July 1982, and its operations have been spectacularly successful, spectacularly successful, until a recent anomaly occurred disrupting direct readout of thematic mapper data through the spacecraft's X-band communication link. This link was to have transmitted thematic mapper data directly to the ground before the TDRSS becomes operational. In the event we are unable to correct this communications problem, information will be once again available when TDRSS becomes operational later this year. The satellite's new Thematic Mapper has provided information of a quality exceeding the original specifications, including valuable information for the geophysical sciences as well as excellent data for mapping and earth resources assessment. Additionally, our earth orbiting scientific satellites and other spacecraft in the solar system have continued to operate and to return extremely valuable scientific information.

In aeronautics, the Department of Defense has recognized the importance of NASA's technical contributions by considering NASA's tilt-rotor aircraft concept as a prime contender for the new joint service JVX vertical take-off and landing aircraft program. The XV-15 experimental aircraft, jointly developed by the Army and NASA, served as the proof-of-concept vehicle which made this recognition possible. Two large new aeronautical facilities are nearing completion, the National Transonic Facility at Langley Research Center and the new 80x120 foot addition to the 40x80 foot Subsonic Wind Tunnel at Ames Research Center. The completion of operational test and checkout of the new 80x120 foot leg has recently suffered a set-back because of an accident during testing. The facility is expcted to be operational in about two years. NASA hopes to repair the facility and return it to operation as soon as possible to minimize delays to a number of priority NASA, DOD, and industry testing programs.

This is just a brief overview of some of the technical achievements of 1982—the list is really much longer. I will talk in more detail about some of the things that have been accomplished later on.

I would now like to turn to another achievement, a renewed commitment to the American space program from the highest levels of this Administration. On July 4, 1982, President Reagan issued a policy statement which outlines basic U.S. goals for activities in space. These goals are: to strengthen the security of the United States; to maintain United States space leadership; to obtain economical and scientific benefits through the exploitation of space; to expand United States private sector investment and involvement in civil space and space related activities; to promote international cooperative activities in the national interest; and, finally; to cooperate with other nations in maintaining freedom of space for activities which enhance the security and welfare of mankind.

The NASA budget request for fiscal year 1984, which I am addressing today, is designed to achieve the objectives outlined in President Reagan's space policy—especially the maintenance of United States leadership in space. This is really the important word—leadership—and this Committee may rest assured that the Administration is strongly committed to what that word represents.

The key to leadership in space is to have efficient and effective ways of getting there. The President's space policy strongly supports the Space Shuttle program, and calls the Shuttle "the primary space launch system for both United States national security and civil government missions."

NASA's proposed fiscal year 1984 budget fully supports a four-orbiter fleet, with enough structural and subsystem spares to make certain that the fleet is able to survive serious delays or accidents. Our proposal will also reduce the lead time for expansion or replacement of the four-orbiter fleet, if and when operational demands require. Our plans make it possible to meet the commitment to launch the payloads which we, and those depending upon us, have planned for at least the remainder of this decade. NASA's first priority, Mr. Chairman, remains: to make the Space Shuttle System fully operational as rapidly as possible. Additionally, we will continue to explore new ways of employing the full capability of the Shuttle. The proposed fiscal year 1984 request continues funding of activities leading to a Shuttle mission to recover and repair on orbit the partially defunct Solar Maximum Mission (SMM) spacecraft in 1984. This will provide more useful life for the important SMM objectives and demonstrate the Shuttle's ability to perform such operations. Later on this year, we are scheduled to fly the first Spacelab mission which is an important demonstration of the new capabilities represented by the Space Shuttle. The Spacelab, developed and contributed by the European Space Agency, represents an important international activity consistent with the President's space policy.

Another international contribution to the Space Shuttle Program is the Remote Manipulator System (RMS) which was provided by the Government of Canada. The RMS successfully completed testing last year and in November was declared ready for operational use aboard future Shuttle flights.

NASA policy has recently been revised to expand opportunities for sponsors of Shuttle payloads to nominate payload specialists to fly with them. President Reagan invited a Brazilian payload specialist to fly aboard the Shuttle, and during his recent discussions with the Prime Minister of Japan, he extended a similar offer which was accepted. Australia and Canada have also accepted invitations for payload specialist nominations.

The second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE '82), held in Vienna last August, helped to promote greater international awareness of the practical benefits of the applications of space science and technology.

In my testimony before this Committee last year, I said that the Space Telescope will be the most important scientific instrument we have ever flown. I continue to believe this is true, and NASA's fiscal year 1984 budget request provides priority support to this very important development effort.

As might be expected in a program of this complexity, we are continuing to experience technical problems, particularly in the Optical Telescope Assembly development activities, which will most likely impact the scheduled launch and runout cost of the Space Telescope. We are currently reviewing a range of alternatives for rephasing the work to minimize the cost and schedule impact. As soon as our evaluation is complete, we will inform the Committee of our proposed actions.

Excellent progress is being made in other areas related to the Space Telescope. In a few months, we will open the doors of the new Space Telescope Science Institute which has been established at the Johns Hopkins University. Software and procedures for carrying out scientific investigations with this very complex space observatory are on schedule. The Space Telescope will open a new era of scientific opportunity and permit the U.S. to retain world leadership in astronomy.

Another measure of leadership in space is the continuing enterprise of planetary exploration. We have included in the proposed fiscal year 1984 budget the intitiation of a new program to map the surface of the planet Venus using radar imaging techniques. Within our overall strategy for planetary exploration, this initiative—the Venus Radar Mapper (VRM), estimated to cost in the $350 million range—replaces, at a much lower cost, the Venus Orbiting Imaging Radar (VOIR) mission authorized by the Congress to begin in fiscal year 1982. The VRM mission will help us understand why our sister planet, Venus, which is so much like the earth in size and physical composition, yet so different in other respects, has followed such a different evolutionary history. We will search for detailed properties in common with the earth, such as volcanic activity and continental drift. Aside from their intrinsic scientific value, observations provided by the VRM will help us to understand more clearly the history, nature, and most importantly, the future of our own planet.

The Advanced Communications Technology Satellite (ACTS) project, another new initiative proposed in the fiscal year 1984 budget, calls for development and flight testing of the high-risk technology needed to ensure continued United States preeminence in the field of satellite communications. The decision to propose the ACTS program is a result ot extensive consultation with communication carriers, satellite system suppliers, and strong support from the Congress. The ACTS program will involve a novel procurement approach, including a cost/risk sharing arrangement with industry which will provide significant cost savings to the government.

Another goal of the President's space policy is to expand private sector investment and involvement in space activities. NASA has received proposals from the private sector to fund and/or operate launch vehicles. We are reviewing these proposals very carefully to determine costs and benefits, launch and tracking requirements, safety and security, as well as international considerations.

In addition to the President's space policy which I have already discussed, the Administration has developed a new policy statement governing the needs for and management of Federally funded research and development work in aeronautics. In November 1982, the President's Office of Science and Technology Policy released a document entitled, "Aeronautical Research and technology Policy." The aeronautics program included in NASA's fiscal year 1984 budget request reflects many recommendations contained in this important policy statement. The most important facet of the Administration's new aeronautics policy is the recognition that a strong aeronautical industry is absolutely essential for both the National security and the health of our economy. Furthermore, this policy recognizes explicitly the important role the Federal Government, through NASA, plays in providing the basic technology which will assist the United States in maintaining and enhancing the leading position in aviation which we now enjoy. In concert with this policy, we are submitting a fiscal year 1984 budget request which continues to emphasize a strong aeronautical research and technology program, including a strengthened fundamental research program which will continue to provide the technical base upon which future aircraft designs can be based.

The centerpiece of our proposed aeronautics program for fiscal year 1984 is the new Numerical Aerodynamic Simulation (NAS) activity, which will be developed over the course of the next few years. The NAS capability will include a large computer system which will make it possible to perform most of the calculations required to design a new aircraft with sufficient accuracy and reliability to significantly reduce the long and expensive process of wind tunnel and flight testing now necessary. There is every reason to believe that the computer technology to achieve this objective can be developed in the next few years, and there is no question that the capability the NAS represents will make it possible to design new airplanes much more effectively. The investment made in NAS will provide incentives for various elements of the computer industry to produce machines which will be able to take advantage of major commercial applications. Developments of this kind will enhance the competitive posture of the United States in this important international market.

The fiscal year 1984 budget proposed by the Administration also contains a number of items which are very important to the future of NASA's health as an institution. It is clear that the achievements I have outlined earlier in my testimony would not have been possible without a strong NASA institution. In the fiscal year 1984 budget before you, there is a substantial increase in funding for Construction of Facilities—$150 million as compared to approximately $100 million in fiscal year 1983. We are also proposing the maintenance of the same number of civil service positions in fiscal year 1984 as we have in fiscal year 1983. The maintenance of our civil service strength is particularly significant because this manpower level will afford an opportunity for NASA to hire some of the best recent graduates of the foremost science and engineering schools in the Nation. We plan to take aggressive steps to bring in the best people we can find in order to strengthen NASA's institution for the long term.

In the past year, Mr. Chairman, concern has been expressed in the press and in the Congress about the appropriate relationship between NASA and those elements of the National security establishment with responsibility for space operations. I would like to take this opportunity to state categorically that this Administration is strongly committed to separate space programs, one dealing with civil sector operations and the other with those related to the National security. The President's space policy is very clear on this point, stating that, "The United States space program will be comprised of two separate, distinct, and strongly interacting programs—National security and civil. Close coordination, cooperation, and information exchange will be maintained among these programs to avoid unnecessary duplication." We have continued to maintain separate programs and to have separate policies governing these programs; but we have also developed a number of new interactive relationships which promote efficient coordination and management while protecting the integrity of NASA programs. We have just finalized a renegotiated Shuttle pricing agreement with the Department of Defense. This new agreement will provide NASA with increased reimbursements of approximately $1 billion more in the next five years than the Agency would have received under the previous policy agreed to in 1977. This revised policy will raise the Shuttle launch cost to DOD by almost 150 percent, in Fiscal Year 1975 dollars, above the previously set launch price. We also have several Memoranda of Understanding with the Department of Defense which deal with various aspects of programs in order to avoid the unnecessary duplication which the President mentions in his space policy.

I would be remiss, Mr. Chairman, if I did not conclude this portion of my testimony by talking about the future. The President's space policy recognizes the importance of developing new concepts which provide a strong vision of the future, not only for our space program, but for the Nation as a whole. In his space policy, the President requires NASA to "continue to explore the requirements, operational concepts, and technology associated with permanent space facilities." The Space Shuttle makes it easier to establish larger permanent facilities in space. NASA's proposed Fiscal Year 1984 budget includes modest funding for definition and planning efforts which will allow us to understand, in greater detail, how such permanent facilities might be developed and maintained in earth orbit. These studies will provide a basis for considering possible future proposals to establish a permanent manned station in earth orbit.

I should stress that we are not now proposing to develop such a space station, but we believe that it is important to understand the uses to which such a capability could be put. We have every reason to believe, Mr. Chairman, that the Soviet Union has learned a good deal about manned operations in space from their experiences with *Salyut 6* and *Salyut 7*. There is also evidence that the Soviets are planning more extensive activities in earth orbit, and we must understand potential benefits of such operations. It is important for the United States to take the necessary steps now to achieve these objectives.

Mr. Chairman, having discussed some of the important highlights, I would now like to proceed with a more detailed discussion of NASA's proposed Fiscal Year 1984 program.

SPACE TRANSPORTATION

For Fiscal Year 1984, the Space Transportation request is $3.498 billion. This includes $1.927 billion for Space Transportation Capability Development and $1.571 billion for Space Transportation Operations.

Since the budget hearings of last year the Space Transportion System has continued to mature. The Space Shuttle Orbiter Columbia made three flights in 1982, completing the Orbital Flight Test Program and initiating the transition into a fully operational system. STS-3 carried the first space science pallet of instruments and demonstrated the practical use of the Remote Manipulator System. STS-4 carried the first DOD payload; and STS-5, the first operational flight, demonstrated a number of "firsts." It was the first time the Shuttle's main engines were run above their rated power level (100 percent) during ascent; the first four man crew; and the first launch of commercial payloads, Telesat-E and SBS-C. STS-5 also carried a getaway canister, four student experiments and a joint endeavor experiment with McDonnell Douglas Corporation, to investigate the commercial potential of separating biological materials in space using a continous flow electrophoresis device. The success of the STS-5 contributed immensely to our image of having an operational system and demonstrated our ability to deliver commercial payloads.

The launch of STS-6 has been delayed from its original planned launch date of January 28, 1983, to a date late this month. The delay has resulted from the discovery of several small leaks in the Shuttle main engines. The leaks are now being repaired on a set of engines which will be reinstalled on the Challenger. We should be able to proceed with STS-6 in March and to minimize our delay for subsequent flights. Additionally, we are developing operational tests and procedures to insure that future flights will not be subject to this type of delay.

The Space Transportation Capability Development Program provides for the National fleet of Space Shuttle orbiters, including main engines, and provides for the launch site and mission operations control requirements, initial spares, production tooling and related activities to meet the needs of NASA, the DOD, and other domestic and international users of space. In addition, this program includes upper stages, Spacelab and advanced programs requirements. In 1983, the third orbiter OV-103, will be delivered for the first operational flight in early 1984. The fiscal year 1984 budget will also allow for completion of the final assembly and integrated testing of OV-104, leading to a delivery at the end of 1984, and the acquisition of orbiter structural spares to support the existing orbiter fleet.

The fiscal year 1984 budget will extend the Shuttle processing and launch capability with the continuing preparations for activating the second launch pad, initial construction funds for the third mobile launcher platform, and modifications to Pads-A and-B to make them Centaur-compatible.

In the upper stages programs, funds are requested to continue the development of Centaur-G, in cooperation with DOD, and Centaur-G prime to support the Galileo and ISPM launches in 1986. We also plan to use the Centaur-G to launch the Venus Radar Mapper in 1988. The budget allows for completion of the IUS vehicles to support four planned TDRSS launches.

The first Spacelab flight is scheduled for 1983. Fiscal year 1984 funds will support post-flight data analysis, and integration and checkout for the second Spacelab verification flight scheduled for fiscal year 1985. Funding is also provided for payload support to the Spacelab 2 and Spacelab 3 missions, Galileo, ISPM, Space Telescope, and the SMM retrieval/repair mission.

In fiscal year 1984, the major emphasis in Space Transportation advanced programs will be to define the system architecture and system elements for possible space operations over the next 20 years. Funding will provide for studies of earth-orbital platforms and facilities; orbital services such as satellite servicing; and advanced transportation concepts for reusable upper stages, teleoperated maneuvering vehicles and Shuttle derived Earth-to-orbit launch vehicle systems. Fiscal year 1984 funding will also provide for the initiation of hardware development of the Tethered Satellite System, a cooperative project with Italy. The Italians will develop the spacecraft and the U.S. will develop the deployment mechanisms and will be responsible for the program management and integration with the orbiter.

The Space Transportation Operations Program provides the standard operational support services for both of the primary U.S. government space launch systems—the Space Shuttle and the expendable launch vehicles. The budget for fiscal year 1984 will provide for production of Shuttle flight hardware (external tanks, solid rocket boosters, engine spares and orbiter spares); maintenance and operation of mission control and crew training systems; and the manpower necessary to support the launches planned for fiscal year 1984. Ten sets of SRB hardware and 11 external tanks are scheduled for delivery in fiscal year 1984.

In November, we awarded a base operations contract for NASA's Kennedy Space Center, to EG&G, Inc., aimed at strengthening support of our launch functions. Under this contract, there will be a clear assignment of responsibility and accountability and a reduction of management interfaces from fourteen to one. In late 1983, we expect to award a Shuttle processing contract which will further reduce the program management complexity and operational costs. The initial start up costs and projected manpower savings are reflected in the fiscal year 1984 estimates. Later, we hope to issue a cargo processing contract to complete the consolidation of our efforts.

We have also taken steps to reduce production costs and increase launch capability. A significant milestone was reached last September when we took delivery of the first lightweight external tank five days ahead of a schedule set in 1980. Our goal was to reduce 6,000 pounds from the previous tank configuration and we actually achieved a 10,000 pound reduction. An additional improvement in payload capability of approximately 5,500 pounds is expected from the new filament wound case, for the solid rocket booster, which is planned for first use in late 1985. Programs are also underway to reduce recurring external tank and solid rocket booster production costs, include modification to the aft skirt structure, modifications in applying and removing tank TPS and development, of low cost solid rocket motor nozzle material.

In the Expendable Launch Vehicles program, the fiscal year 1984 funding reflects the requirements to support the Delta launch vehicle's missions. We have recently determined that the number of vehicles to be procured for non-NASA missions should be reduced commensurate with the revised reimbursable launch requirements. The Delta system is planned to be operational at least until 1986 to support the launch requirements of the National Oceanic and Atmospheric Administration.

SPACE STATION PLANNING ACTIVITIES

Last May, I established a Space Station Task Force to provide focus and direction to the Agency's planning activities for this potential major new initiative. The planning effort will be continued and expanded modestly in fiscal year 1984 in order to generate the information, including costs and benefits, necessary for the Administration and Congress to make an informed decision on whether to proceed with some form of more permanent space facilities.

NASA's fiscal year 1983 planning activity is focused upon understanding exactly what a space station could do, emphasizing the several areas of endeavor that utilize space: science, applications, technology development, National security, and commerce. We have deliberately steered away from design and configuration, directing our attention, and that of other interested parties, than to mission reqirements and "architecture." Our goal is to have a thorough understanding of space station functions and the consequent attributes a station would require to carry out specific missions. Last summer, we sponsored eight small industry studies of potential space station missions. These are on schedule and will be completed shortly. Their results will be synthesized into potential time-phased mission sets which could be accomplished by a station in space. In addition, we have held discussions with our scientific and technical advisory committees, potential international partners and the Department of Defense to encourage them to review space station missions.

NASA's fiscal year 1984 request includes $6 million within Space Transportation Advanced Programs which will be used primarily for space station systems engineering activities. An additional $6 million is included to augment on-going efforts in the fiscal year 1984 Space Research and Technology program, principally to focus on key technology activities. In addition, $2 million is requested in the Space Science and Applications program primarily for studies of science and applications payloads applicable to a space station. Fiscal year 1984 planning calls for identification of an "architecture" which could accommodate a preferred mission set, and further refinement of conceptual approaches.

SPACE SCIENCE AND APPLICATIONS

The past year's highlights for the Space Science and Applications program, in addition to the Landsat 4 launch, include the recent launch of the Infrared Astronomy Satellite (IRAS), and the outstanding early success of the Search and Rescue Satellite project.

Landsat 4 was launched in July, to provide more sophisticated and reliable data on earth resources. Landsat 4 carries a flight-proven Multispectral Scanner (MSS) and Thematic Mapper (TM) instruments for remote sensing. Data from these instruments have surpassed all expectations. The improved ground resolution and extended spectral range provided by the Thematic Mapper will enable users to recognize subtle differences in forest species, agricultural conditions, soil moisture and water turbidity that could not be detected in earlier MSS imaging. Approximately 4,000 TM scenes of the continental United States have already been acquired and archived during the first six months of Landsat 4 operations, and several research programs are now underway to evaluate in detail the quality and scientific utility to the Landsat 4 imagery. Unfortunately, on February 15, 1983, an anomaly occurred disrupting direct readout of thematic mapper data directly to the ground before the TDRSS becomes operational. In the event we are unable to correct this communications problem, information will be once again available when the TDRSS becomes operational later this year.

IRAS, an extremely difficult and technologically challenging mission, developed in cooperation with the Netherlands and the United Kingdom, will execute the first comprehensive survey of the infrared sky, providing a new window to the universe. It is expected to revolutionize astronomy in the same way that the first ultraviolet and X-ray satellites did in the last two decades.

The Search and Rescue Satellite project, another significant international cooperative endeavor, began system checkout in September, and demonstrated its effectiveness almost immediately when a small aircraft which had crashed in a remote region in British Columbia was detected by the system. The injured pilot and two passengers were rescued. By mid-November, the new system was directly credited with saving ten lives in aircraft and marine accidents.

Our fiscal year 1984 budget request of $1068.0 million for Space Science and Applications supports the two new initiatives I mentioned earlier—the Venus Radar Mapper and the Advanced Communications Technology Satellite—and will enable us to pursue a vigorous program. The proposed budget supports the completion of the Landsat-D' spacecraft; it continues the Space Telescope development leading to a launch in 1985. As indicated earlier in my statement, we are currently reviewing the Space Telescope project; review will likey lead to revised schedule and runout cost estimates. The fiscal year 1984 budget also continues Galileo development leading to a single Shuttle/Centaur launch in 1986; and it continues International Solar Polar Mission (ISPM) instrument development support leading toward launch in 1986. It continues the hardware development of the Gamma Ray Observatory (GRO) leading toward a planned launch in 1988. It supports a 1984 launch for the Earth Radiation Budget Experiment (ERBE); technology development and analysis of flight experiments in Materials Processing; operation of the Pioneer Venus Orbiter, Pioneers 6 through 11, and Voyagers 1 and 2; support for the Infrared Telescope Facility and the Lunar Curatorial Facility; and continued development of experiments to understand the effects of weightlessness on man.

The Explorer development funding level is somewhat higher than in fiscal year 1983 because this program offers important opportunities to address key space science questions in a highly cost effective manner. This level of fiscal year 1984 funds will allow us to complete development of the Active Magnetospheric Particle Tracer Explorer (AMPTE), a project to determine how particles from the solar wind enter the Earth's magnetosphere; will support development activities for the Cosmic Background Explorer (COBE) satellite. The fiscal year 1984 program will support initiation of the Extreme Ultraviolet Explorer (EUVE), which is expected to reveal new information on the structure and composition of interstellar media.

This proposed Space Science and Applications budget represents a commitment to maintain the momentum in scientific and technical excellence that has had such an important impact on the Nation and the world. It will continue the outstanding effort of the past, initiate new activities, and assure the preservation of the scientific research base that is critical to United States leadership in space.

TECHNOLOGY UTILIZATION

For fiscal year 1984, we are requesting $4 million for Technology Utilization to continue the transfer of NASA-developed technology to U.S. industry, the public and other Government agencies. We have two primary program objectives: (1) to target applications engineering efforts to increase productivity in U.S. manufacturing industries, and (2) to improve the quality of life and workforce through bioengineering and rehabilitation projects. We intend to enhance public sector technology applications projects in conjunction with other mission-oriented Federal agencies and industry with a view toward shifting budgetary responsibility for resultant projects to those entities.

AERONAUTICAL RESEARCH AND TECHNOLOGY

In fiscal year 1984, a total of $300.3 million is requested for NASA's Research and Technology program, to provide the technology advances essential to the continued U.S. leadership in aeronautics. A strong base of technology is needed to develop future U.S. aircraft which will enhance our competitive position in the world aviation marketplace, and to provide continued superiority of the Nation's military aircraft. NASA's fiscal year 1984 budget request continues to emphasize a strong fundamental research and technology base of activities as well as focused systems research activities, and constitutes a balanced effort in response to the Administration's recently enunciated aeronautics policy.

In fiscal year 1984, emphasis in fluid and thermal physics will be applied to turbulent drag reduction, internal computational fluid dynamics, and high Reynolds number cryogenic testing to be provided by the National Transonic Facility at NASA's Langley Research Center. This facility, which will become operational in June 1983, will provide the most advanced transonic speed test capability in the world. Using models of the world's most advanced aircraft, this facility will allow near exact simulation of flight conditions. Areas of emphasis in materials and structures will include ceramics, new composite materials, and transport crash dynamics. In controls and human factors, new research capabilities will be provided by the Man-Vehicle Systems Research Facility at the Ames Research Center and the Avionics Integration Research Laboratory at the Langley Research Center. The upgrading of capabilities in computer science and applications will continue to receive major emphasis, with expanded efforts directed toward technology for fault tolerant systems. In propulsion, emphasis will be placed on intermittent combustion engines, helicopter and turboprop transmissions, engine dynamics and stall recovery, and small radial turbomachinery. Rotorcraft research will stress noise and vibration reduction and the unsteady aerodynamics of rotors. Research will also be conducted to investigate guidance and control for all-weather rotorcraft operations, composite tilt rotor blades and technologies aimed at improving performance and flying qualities of the tilt rotor vehicle class. Areas of emphasis in high-performance aircraft research will include supersonic cruise technology, hypersonic propulsion, structures, configuration aerodynamics, and propulsion/airframe integration. Also included will be flight evaluations of advanced concepts using special F-16 and F-111 aircraft to investigate new technologies for enhancement of fighter performance. The proof-of-concept flight research phase of the NASA/Defense Advanced Research Projects Agency (DARPA) X-29A forward swept wing vehicle will begin, and increased effort will be provided in the Turbine Engine Hot Section Technology program to study means for increasing engine performance and durability. In subsonic aircraft, research emphasis will be placed on commuter aircraft technology, icing and lightning research, natural laminar flow, and problem areas identified in coordination with the Federal Aviation Administration as critical to improved air safety and operations.

In fiscal year 1984, program augmentations are planned in the important long-lead, high-risk technology areas: numerical aerodynamic simulation, large composite structures, and rotorcraft. The Numerical Aerodynamic Simulation initiative will significantly augment the Nation's program in computational fluid dynamics and other areas of computational physics. It will provide advanced capability for users nationwide for computational aerodynamics, computational chemistry, and other complex analytical problems. Advanced composite structures technology will address thick, load-critical primary structures representative of large aircraft wing-structure sections; curved panels to investigate fuselage design technology problems; and new generation materials for increased toughness and impact resistance. Technology for next-generation rotorcraft will pursue further understanding relative to two high-speed rotorcraft concepts—the advanced tilt rotor technology and the DARPA X-wing utilizing NASA's Rotor Systems Research Aircraft.

SPACE RESEARCH AND TECHNOLOGY

NASA's fiscal year 1984 Space Research and Technology request of $138 million will focus on providing advanced technology in support of NASA's role of maintaining the U.S. preeminence in space. This investment in research and technology is essential for improving operational capability, reliability, and affordability of existing and planned NASA missions, as well as providing the technology base and technology options for rapidly expanding military and commercial space interests.

The fiscal year 1984 budget continues to emphasize a strong Research and Technology (R&T) base of activities in the discipline areas of fluid and thermal physics, chemical propulsion, materials and structures, computer science and electronics, space energy conversion, controls and human factors, and space data and communications. The computer science and space human factors disciplinary activities represent new elements in the R&T base that respond to important future systems needs, as well as to identifiable, high-leverage, technological advancements. In addition, activities in spacecraft, transportation, and platform systems research are designed to study the inter-relationships of discipline technology from an integrated systems point of view. These efforts are critical to the successful transition of technology from the laboratory to useful application. It is encouraging that a cooperative program around NASA, DARPA and DOE on space nuclear power technology was reached and a Memorandum of Understanding was signed on February 11, 1983. In fiscal year 1984, a modest expansion to the base program in platform systems is planned to investigate technology options that could enhance capabilities and growth potential of permanent space facilities.

The Systems Technology effort in fiscal year 1984 will focus on the following technology missions or experiments: launch of the long-duration exposure facility, the solar array flight experiment, solar cell calibration facility, tribology experiment, reflight of the feature identification and location experiment, launch of the ion auxiliary propulsion system, design activity on a space technology experiment platform, and a cryogenic fluid management facility.

ENERGY TECHNOLOGY

During the past year, NASA has continued to support the Department of Energy (DOE) and other agencies in energy research and technology development. Important progress was made by NASA's Lewis Research Center in advancing ceramic component technology for the automotive gas turbine, and in improving the life and performance of advanced phosphoric acid fuel cell systems.

In fiscal year 1984, NASA will continue to support those energy programs which were initiated in prior years, and which the DOE or other sponsoring agencies desire NASA to continue. We intend to complete our previous commitments as efficiently as possible to ensure the integrity of the government investment made to date. For the future, it will be our policy to concentrate on energy programs which have objectives which are synergistic with NASA's aeronautics and space programs.

SPACE TRACKING AND DATA SYSTEMS

For the Space Tracking and Data Systems program in fiscal year 1984, NASA is requesting a total of $700.2 million, which includes $294.7 million for acquisition of service via the Tracking and Data Relay Satellite System (TDRSS) as well as support of TDRSS related elements. This request provides for the continuation of the vital tracking, command telemetry and data acquisition support to meet the requirements for all NASA flight programs.

The Spaceflight Tracking and Data Network (STDN) and the Deep Space Network (DSN) will continue to provide support to both near-Earth orbiting satellities, including the Space Shuttle operational flights and deep space probes. In fiscal year 1984, numerous applications and scientific Earth-orbiting and planetary missions will be supported.

The launch of the first and second TDRS spacecraft are scheduled to be launched in 1983. The TDRSS is planned for full operational capability in 1984. The TDRSS service contract has been restructured to convert the TDRSS from a shared system providing both support of government space missions and commercial communications satellite services, to a system dedicated to providing support to space missions. The fiscal year 1984 budget request reflects the initial full year funding requirements for TDRSS service and the phaseout of most of the STDN ground stations after TDRSS is operational. Ground stations planned to be closed during fiscal year 1984 are Guam, Hawaii, Ascension, Santiago, Dakar, and Botswana, with termination of STS VHF voice communications from Yarragadee, Australia, and the AF

Indian Ocean site. The remaining facilities will then be consolidated with the DSN stations under management of the Jet Propulsion Laboratory (JPL), or dedicated to support of launch and landing operations. The consolidation will result in a single ground network to support geosynchronous, highly elliptical, and all planetary missions.

CONSTRUCTION OF FACILITIES

The Construction of Facilities (CoF) request for fiscal year 1984 totals $150.5 million. Slightly over one-third of the request, $53.3 million, is required for Space Shuttle and payload facilities. The request includes $24 million for aeronautics and space technology activities and $58 million for repair, rehabilitation and modification, minor construction, and facility planning and design. The fiscal year 1984 CoF request strikes an appropriate balance between NASA's need to meet increasing Shuttle flight rates, improve Shuttle manufacturing and processing efficiencies, provide enhancements of existing facilities to afford improved research and testing capabilities, and to repair and preserve our present physical plant.

The Space Shuttle CoF projects are in direct support of achieving a 24-flight-per-year capability. Based on the experience to date, it is NASA's current assessment that two Mobile Launcher Platforms (MLP'S) can support up to 16 flights per year. Thus, the project for modifying a third mobile launcher platform for Shuttle use, at a cost of $27.3 million, is required to reach 24 flights per year from NASA's Kennedy Space Center (KSC). The other large Shuttle-related projects reflected in the request are the construction of a Cargo Hazardous Processing Facility at KSC ($9 million), and some additional modifications to the External Tank (ET) manufacturing facilities ($11.7 million) at the Michoud Assembly Facility in New Orleans.

In the non-Space Shuttle area, our fiscal year 1984 construction request is similar to those of recent years, providing for prudent investments necessary to preserve and improve existing research facility capabilities. An example is the Small Engine Component Testing Facility proposed for construction at NASA's Lewis Research Center. Modification of test cells in the Engine Research Building at LeRC are necessary in order that a critical need for testing and development of small turbine engines can be met. This project is typical of our continuing emphasis on modifying and improving existing facilities to meet new research and technology needs of the country.

Of equal importance is the $58 million requested in fiscal year 1984 for minor facility projects. These are critical to the repair and preservation of an aging physical plant and to ensure that NASA's facilities are capable of meeting today's technology needs.

RESEARCH AND PROGRAM MANAGEMENT

The Research and Program Management request for fiscal year 1984 is $1,247.5 million. About three-fourths of this is required for civil service salaries and related costs. About two percent is for travel which is vital to the management of our R&D programs. The balance is for facility support and related goods and services necessary for the operation of NASA Centers.

The fiscal year 1984 plan provides for a NASA civil service workforce at approximately the present level, the first time in several years that we have not been planning to accomplish some kind of personnel reduction in the current and budget years. Staffing stability of this kind is important for an R&D organization such as NASA. It allows us the opportunity to hire new scientists and engineers to assure the vitality of our technical workforce. It will also enable us to solve minor skill-mix problems that arose in previous years when we were faced with accommodating ceiling reductions. In fiscal years 1983 and 1984 we will be able to plan our hiring in a more effective manner. Although I believe that NASA's workforce is one of the strongest and most creative in the world, we need the influx of people with new viewpoints, different skills, and knowledge of the latest technology in many diverse areas to maintain and improve this outstanding national asset.

The requested R&PM funds will provide for essentially the same level of operations in fiscal year 1984 as planned in fiscal year 1983, considering estimated price levels which are expected to rise at a significantly slower rate than we have experienced in the past years.

As you are aware, the President is very interested in increasing the productivity and improving the quality of all governmental activities. In order to provide leadership in this area and to provide coordination for the many productivity-related activities in both Headquarters and at the Centers, I have formed a steering committee composed of the top management officials of the Agency. The steering Committee is focusing on our overall goals of (1) maintaining NASA as a leader in the development and application of advanced technology and management practices which contribute to significant increases in both Agency and National productivity and quality; (2) identifying areas where NASA practice is behind the state-of-the-art in productivity and quality and to initiate actions to effect improvement; and (3) enhancing awareness among management, the workforce and our contractors of the need to achieve increases in our productivity. We are already moving on some specific productivity initiatives in reducing paperwork throughout the Agency, in introducing common and shared administrative automatic data processing systems and coordinating an Agency-wide plan for information through office automation.

Finally, I am pleased to point out that, even with the significant civil service personnel reductions in fiscal year 1982, we were able to improve the ratio of minority and female professional employes in the NASA workforce. Last year the ratio of minority professionals in the workforce rose from 8.4 percent to 8.7 percent, and for females in professional position from 11.6 percent to 12.2 percent. Consequently, minority and female professionals now make-up 19 percent of NASA's professional workforce and 28.7 percent of the total workforce.

CONCLUSION

In conclusion, Mr. Chairman, I believe that NASA's fiscal year 1984 budget request represents a well-balanced program which fully funds the Space Transportation efforts, provides for continuing programs in Science, Applications, and Aeronautics, and reflects several important new Research and Development initiatives. This request also reflects, significantly, an augmented Construction of Facilities program, and a stabilized NASA civil service workforce level. I trust that the Committee will recognize this as a balanced and healthy proposal, which reflects the Administration's commitment to a vital U.S. civilian space program, and that the Committee will fully support NASA's proposed fiscal year 1984 budget.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—BUDGET SUMMARY

[Thousands of dollars]

	Budget Plan		
	1982	1983	1984
Research and development:			
Space transportation systems	3,089,900	3,597,800	3,498,000
Space science and applications	896,200	1,034,100	1,068,000
Technology utilization	8,000	9,000	4,000
Aeronautical research and technology	264,800	280,000	300,300
Space research and technology	111,000	123,000	138,000
Tracking and data acquisition	402,100	498,900	700,200
Total research and development	4,772,000	5,542,800	5,708,500
Construction of facilities	113,700	97,500	150,500
Research and program management	1,134,400	1,199,050	1,247,500
Total	6,020,100	6,839,350	7,106,500
Outlays	6,035,401	6,721,500	6,981,100

[The following information was subsequently received for the record:]

Questions submitted by Senator Gorton during the Senate Authorization hearing on March 9, 1983.

FIFTH ORBITER

Question 1: In January the Aerospace Safety Advisory Panel (ASAP) submitted to NASA a list of recommendations which included the redesign of the Space Shuttle main engine turbomachinery and landing gear, tires and brakes. We are also aware of the multiple problems on Shuttle STS-6. What is NASA's policy for correcting these difficiencies? Does the $100 million budgeted for spare parts in the FY 1984 budget provide for redesign of any parts that are considered unsafe or are unreliable or for purchase of current design parts only?

Answer 1: We are currently in the process of assessing each recommendation of the Aerospace Safety Advisory Panel (ASAP) and we have not formulated final responses to the recommendations. However, our current program plan includes activities which address many of the items in the ASAP report.

The SSME Program Plan for FY 1984 includes a small initial investment for SSME life improvements and engineering redesigns of critical life - limiting components of the engine. The turbomachinery identified in the ASAP report is one of the planned areas of redesign activity for FY 1984. The initial funding for this redesign effort is at a level of $4 million for FY 1984.

The landing gear, tires and brakes as originally designed were marginal especially in light of the increased orbiter landing weights, especially the abort landing weights, under worse case crosswind conditions. Improvements have been incorporated in the original design. The main tire ply rating was increased from 28 to 34 and a spacer has been added to prevent axle deflections from damaging the brakes. Protective steel covers are planned for the brake rotor lugs prior to STS-7.

The improvements were designed to remove the landing gear from the marginal category. Tests and analyses are now being conducted to verify the gains these improvements offer for maximum proposed landing loads. Should the test and analyses indicate the need, further improvements will be made as required.

Question 2: Your testimony indicates that the FY 1984 budget supports a four-orbiter fleet, "with enough structural and subsystem spares to make certain that the fleet is able to survive serious delays or accidents".

a. Would you define "serious delays or accidents?"

b. Would that extend to total loss of an orbiter?

c. Does the present launch slippage of STS-6 qualify as serious?

d. Will the $100 million in the budget as spares be fully adequate to prevent launch slippages of two-three months? If not, what would be an appropriate funding level to prevent such delays?

Answer 2:

a. A serious delay or accident would be one that is major in nature. An accident which caused major structural damage is one example. An accident of this type causing damage to wings or tails, as examples, would result in serious delays as the structural element would have to be replaced. The structural spares procurement program included in the NASA FY 1984 budget is designed to lessen the impact of such an accident as the structural part would be readily available for use.

A serious delay could also be caused by the unexpected breakdown of a major integral system which would impair the orbiter's ability to fly without replacement or repair of the system. Replacement of such a system could require significant effort, potentially involving systems analysis, engineering and redesign.

b. Total loss of an orbiter would certainly represent a serious delay or accident as there would likely be a period of no-flights while investigations and analysis were made to determine the cause and to ensure that no generic fault was present which would endanger the remaining fleet. Should a total loss occur and a replacement orbiter is required, the availability of the structural spares, discussed in answer 2a. above, would substantially reduce the time necessary to build an additional orbiter.

c. The delay on STS-6 is viewed by NASA as serious but obviously in a different context from the serious delays and accidents discussed above. Delays of the type now being experienced have impacts on the flight schedule, on costs and on user confidence. However, we believe the STS-6 problems are still part of the STS learning process and should not be viewed as serious STS faults.

d. There is a total of $420 million planned for structural spares over five years with $100 million in the FY 1984 budget. These spares would be available to support repairs to an orbiter in case of major structural damage. They will not prevent slippages of two-three months as is occurring on STS-6 as problems of this nature would not benefit from the availability of structural spares. However, our logistics program is designed to provide adequate spares support to prevent slippages due to the need for normal spare parts.

Question 3: What are the prospects that Department of Defense (DOD) might require that an orbiter be reserved for its own missions? If there are such prospects, when might such a decision have to be made?

Answer 3: NASA and DOD have always recognized the policy of interchangeability of orbiters for missions and launch sites. The dedication of orbiters would more likely be done for mission classes to enhance turnaround efficiency. In the later 1980's, based on traffic requirements, an orbiter may be reserved for use at the Vandenberg Air Force Base (VAFB) launch site where the majority of the missions are sponsored by the DOD. However, the orbiter would still be interchangeable for use at Cape Canaveral as dictated by mission and schedule needs.

Question 4: Under what circumstances would you expect DOD to "bump" STS-9 to assure the scheduled launch of STS-10?

Answer 4: We do not expect to "bump" STS-9 under any of the options under consideration. STS-9 utilizes Orbiter 102 while STS-10 uses Orbiter 099. The STS-9 Spacelab mission is keyed to the availability of the Tracking and Data Relay Satellite (TDRS) capability and to science constraints posed by orbital mechanics.

If STS-9 is not launched as currently scheduled in late September or early October, it would probably slip to a launch slot beyond STS-10.

Question 5: Ariane has targeted 30 percent of the market for launch vehicle activity. Has NASA targeted a percentage of this market as an appropriate market share?

Answer 5: No, NASA has not yet articulated a comparable market share target. The Ariane goal of achieving 30 percent of the market for launch vehicle activity is most probably aimed at the commercial satellite market; the commercial satellite market itself represents about one-fourth of all Shuttle flights, with DOD about one-half and NASA being roughly one-quarter.

Question 6: What would be the cost of a fifth orbiter if procurement were initiated in FY 1983? In FY 1984? In FY 1985?

Answer 6: At present, there is no authorization to procure the fifth orbiter in FY 1983, and NASA has not requested such an authorization to proceed in FY 1984. Assuming that the Congress authorized and appropriated funds in FY 1983 for the fifth orbiter, it is judged unlikely that any significant level of activity could be attained in FY 1983 due to procurement lead times. The cost of a fifth orbiter, (without any supporting systems that would be required) if procurement were initiated in either FY 1983 or FY 1984, would accordingly be approximately the same--$1.8 billion. An FY 1985 decision to proceed would involve a commitment to approximately $1.9 - 2.0 billion in total procurement cost.

Question 7: How do the Government estimates for Shuttle payload demand anticipate private/commercial use?

Answer 7: The non-Federal demand for Shuttle use encompasses two perspectives: (1) the near-term demand comprised of firm launch requests, and (2) the longer range anticipated demand evolving from a continuation of near-term commitments and other programs now in the development phase.

Specifically, the near-term commitments are dominated by the operational communications satellite business. These payloads constitute the equivalent of up to four to five Shuttle launches per year in the mid to late 1980's. The near-term also includes non-communications commitments, principally in the materials processing arena, amounting to one-half to a full equivalent Shuttle launch per year for research and development purposes.

Some optimistic long-range projections include a continuation of launches for near-term communications satellite customers and a gradual growth of new communications satellite customers as the direct broadcast, video conferencing and other systems are perfected. In the decade of the 1990's, this demand is optimistically projected to grow to six equivalent Shuttle launches per year. Other launch demands are expected to arise from the materials processing developments currently underway. This demand may add additional Shuttle flights to the overall non-Federal annual launches. Therefore, through the 1990's some optimistic projections show as many as five to six Shuttle launches will be required to accommodate demand.

Question 8: Is private sector funding of a fifth orbiter an acceptable alternative to NASA? What is the status of your negotiations with Spacetran?

Answer 8: NASA feels that there are benefits to both the Government and the private sector which can be derived from such endeavors. NASA is also aware that it must carefully evaluate both the potential benefits and the problems for both sectors in the process of making a determination on the merits of each specific proposal. Concepts such as this one are, in principle, consistent with the national policy of increasing private sector involvement and investment in space activities.

NASA has held a series of discussions with the Space Transportation Company with an objective of exploring and gaining a better understanding of the concept proposed. The Space Transportation Company has indicated that, on the basis of these discussions and the FY 1984 budget, it is preparing a revised and more complete submission to NASA. We hope to be able to complete a thorough evaluation of this revised proposal after its submission by the Space Transportation Company.

EXPENDABLE LAUNCH VEHICLES

Question 9: Your testimony indicates that your "plans make it possible to meet the commitment to launch payloads which we and those depending on us, have planned for at least through the remainder of the decade." When do you plan to cease the procurement of the expendable launch vehicles (ELV's)?

Answer 9: Expendable launch vehicles under NASA control consist of the Scout, Delta, and Atlas Centaur. These vehicles are planned to be phased out of USG use after all firm launch commitments, currently under contract, are satisfied. These launch commitments extend into calendar year 1986 for Delta and 1987 for Atlas Centaur. To satisfy these commitments, procurement of the launch vehicle hardware has been placed on contract for delivery in the near future or the hardware is already built and is in the NASA inventory. Attached is a status of the Expendable Launch Vehicle inventory as of December 31, 1982. (Table A)

Question 10:

a. Is there any concern that abandoning ELV's and relying totally on the Space Shuttle would leave NASA particularly vulnerable to the loss of an orbiter or critical spare parts?

b. Might elimination of the ELV's have an negative impact on commercialization of Shuttle launch services?

Answer 10:

a. No, we believe that a Shuttle fleet of four operationally proven orbiters will provide a capability to cover the Nation's space needs and have sufficient capacity to provide support for commercial and foreign needs. Based on our experience with launch systems and aircraft, we do not anticipate any long periods (exceeding three to six months) of down time for an orbiter.

b. Elimination of Government operation of the current stable of expendable launch vehicle should not have a negative impact on commercialization of Shuttle launch services. In fact, the elimination of ELV's, if they are eliminated as Government owned and operated and reestablished as private commercially owned and operated endeavors, may well be a test bed for commercialization of the Space Shuttle; much of the experience gained from ELV commercial ventures would have the potential for applicability to commercialization of the Space Shuttle.

UPPER STAGE

Question 11: Is there any planning going on at NASA or between NASA and DOD for a higher energy upper stage than Centaur? Have both civilian and defense applications been identified?

Answer 11: NASA is planning to initiate preliminary studies of a high-performance, reusable orbit transfer vehicle. Two parallel, competitive studies are contemplated. Many potential applications have been identified, particularly with respect to commercial satellites and platforms. We are working with the DOD to keep them advised of and involved in our planning studies.

SHUTTLE PRICING POLICY

Question 12: DOD, in its testimony before this Subcommittee, said the DOD reimbursement will be the same price per launch as that of commercial users for equivalent service, excluding manpower charges which will be traded between the Air Force and NASA.

Is the difference between the commercial rate ($38 million in FY 1975 dollars) and the DOD rate ($29.8 in FY 1975 dollars) consumed entirely by the difference in manpower charges? If not, what other charges are included in this difference?

Answer 12: Under the agreement between NASA and the DOD, the DOD pays for items termed "Materials and Services" which include: orbiter hardware spares, crew equipment, main engines, solid rocket boosters, external tanks, and contract administration. These items are included in the DOD price of $29.8 million (FY 1975 dollars). The remaining cost items are exchanged between the agencies. The difference between the charges to the DOD and commercial customers, consists largely of the manpower charges for launch and flight, but also includes propellants and ground support equipment spares. Under the agreement, NASA will fund for propellant and ground spares for Kennedy Space Center; DOD will fund for propellants and ground spares at Vandenberg. In addition, the commercial price of $38 million includes a $4 million contingency charge that is not incorporated into the DOD price.

Question 13: Please provide a comparable current cost-per-flight estimate for the first 12 years of Shuttle Operations comparing it to the June 1976 and September 1980 estimates. State the total number of flights upon which this estimate is based and the number of flights from each launch location.

Answer 13: A comparison of the flights planned for the first twelve years of Shuttle Operations from the east coast and west coast launch sites is as follows:

	1976 572 Model	1980 487 Model	1983 234 Model	1983 312 Model
Kennedy	399	362	184	240
Vandenberg	173	125	50	72
	572	487	234	312

For east coast launches, the estimated cost per flight over the mission model is as follows:

(Estimates in Millions of 1975 dollars)

572 Model	487 Model	234 Model	312 Model
$16.25	$26.00	$57.20	$46.49

These cost estimates include allocations of some support costs and center overhead costs. The current estimates result from an analysis done in 1982 in support of the pricing policy reviews.

Question 14: Does NASA's Space Shuttle pricing policy provide for recoupment of the Government's capital investment in the orbiter fleet, equipment, and facilities?

Answer 14: The NASA pricing policy established in 1977 for non-U.S. Government launches in the first three years of operations included, which provided for a use fee which is applied to commercial and foreign customers, share of the depreciation of facilities and equipment and the amortization of the investment in the orbiter fleet. The pricing policy for launches in FY 1986-1988 is now based on out-of-pocket costs and, therefore, does not include such a use fee.

Question 15: How does the $16 million (1975 dollars) price for DOD launches in FY 1984 and FY 1985 compare to the estimated cost per flight for DOD launches in those years.

Answer 15: The original memorandum of agreement between the Department of Defense and NASA specified that the DOD would reimburse NASA $12.2 million (in 1975 dollars) for the average materials and services costs incurred in support of a dedicated mission during the first six years of Shuttle operations. This value for materials and services is also incorporated into the present $18.0 million (in 1975 dollars) standard Shuttle launch services charge which other U.S. Government, commercial and foreign customers are paying for launches in the FY 1983-1985 period.

The current memorandum of agreement between DOD and NASA calls for the DOD to reimburse NASA $16.0 million for materials and services costs for launches through FY 1985 and $29.8 million (both in 1975 dollars) for launches during FY 1986-1988. This significant departure from the original memorandum of agreement took into consideration not only the increase in the average materials and services costs but also the change in Shuttle flight planning from a very rapid build-up in flight rate to a more gradual build-up. Thus, the current average materials and services costs for FY 1983-1985 of approximately $47 million (in 1975 dollars) is strongly influenced by the relatively low production rates and consequent lack of near-term economics of scale.

It should also be noted that the DOD is the only customer during this FY 1983-1985 period whose price has been increased in partial compensation for the increase in the Shuttle cost per flight.

Question 16: How does the $29.8 million (1975 dollars) price for DOD launches in FY 1986-1988 compare to the estimated cost per flight for DOD launches in those years?

Answer 16: The estimated average cost of a Shuttle flight within the FY 1986 through FY 1988 period is $55.5 million (FY 1975 dollars). The cost includes all materials, services, direct manpower and allocations of support manpower required for a dedicated KSC Shuttle launch. The current memorandum of agreement between the DOD and NASA includes a general principle that each portion in the National Space Transportation System will provide, at no charge, the manpower necessary to operate the Shuttle related facilities for which they are responsible. The $29.8 million (FY 1975 dollars) price for DOD launches in this timeframe represents the estimated recovery of materials and services not included in this exchange of support agreement.

Question 17: Will DOD reimbursement for launches through FY 1988 be equal to or exceed the estimated launch costs? If not, how much funding support must NASA provide through FY 1988 for DOD launches?

Answer 17: A key premise of the pricing policy is recognition of their multi-billion dollar commitment to the national Shuttle capability. Accordingly, NASA and the DOD do not reimburse one another for manpower related to providing an operations capability at the STS facilities. DOD will reimburse NASA for all the materials and services costs for launches through 1988. The manpower costs for their launches will not be reimbursed in accordance with the recently signed memorandum of understanding. The pricing policy established for FY 1985-1988 reflects full recovery of the estimated materials and service costs.

Question 18: Will NASA be permitted to adjust the DOD price in FY 1989 and beyond to recoup prior losses from DOD?

Answer 18: An updated pricing policy will be developed for FY 1989 and beyond, probably during FY 1985. NASA does not intend to recoup prior losses from the DOD. The current pricing policy for FY 1985-1988 is based on full recoupment of the currently estimated costs applicable to DOD flights. The NASA/DOD Reimbursement Policy Memorandum of Agreement is based on recognition of DOD as a unique contributing partner to the national Shuttle capability. NASA does not view DOD flights as being flown at a loss to NASA. Considering that DOD has committed over $15 billion to the Shuttle and its related activities through FY 1988, the DOD has made a significant contribution to the national Shuttle capability.

Recognition of DOD's partnership is a key element of the new pricing policy.

Question 19: What is NASA's estimate as to when the DOD launch price will equal the actual DOD launch costs?

Answer 19: The launch price for FY 1985 through 1988 equals the estimated cost of those materials and services applicable to DOD flight. These materials and services are exclusive of the NASA manpower costs, propellants and ground support equipment spares which are traded for similar services provided by DOD at Vandenberg and the DOD ranges.

Question 20: Did the mechanics of establishing a launch price under the revised NASA/DOD agreement inlcude consideration of offsetting costs? If considered, please identify the NASA and DOD cost items that were offset and the estimated cost of each item.

Answer 20: Yes, the revised NASA/DOD agreement includes consideration of off-setting costs. The fundamental premise was that DOD and NASA are partners in the development of the National Space Transportation System. Within this context, NASA and DOD agreed to provide the manpower required to operate those Shuttle-related facilities for which each is responsible without charge for standard Shuttle services. In addition, the pricing policy reflects provision of launch-related propellants and ground support equipment spares at KSC and Vandenberg on a similar basis. Implementation of these principles results in NASA providing the propellants, ground support equipment spares, and launch operations for all DOD flights out of KSC and VAFB prior to completion of their planned consolidated Space Operations Center. The DOD provides the propellants, ground support equipment spares, and launch operations support for all flights out of VAFB, and range support for all flights at KSC and VAFB.

This agreement is recognition of DOD's major contribution to the national Shuttle capability. DOD has a multi-billion dollar commitment to the Shuttle (over $15 billion through FY 1988). DOD's contribution is approximately one-third of the total Shuttle cost. This contribution remains proportional to DOD's projected usage of Shuttle capability.

These offsets were agreed to as general principles and no specific cost calculations were performed that would be applicable to the specific FY 1985 through FY 1988 timeframe incorporated in the revised pricing agreement.

Question 21: The Air Force has estimated that the revised NASA/DOD pricing agreement will cost DOD an additional $1.5 billion to $2.0 billion for its use of the Shuttle over a several year period. What period of time does this estimate cover? Does this estimate include any factors other than payments to NASA? If so, please identify. Does NASA agree with this estimate?

Answer 21: The DOD projection of $1.5 to $2.0 billion represents the increase in projected DOD payments to NASA through FY 1988 and includes Shuttle flight charge payments and the funding of standard range support. It represents the difference in payments between the new pricing policy and the old ($12.2 million FY 1975 dollars) pricing policy required to fly the DOD FY 1984 President's budget mission model. NASA had previously calculated a difference of approximately $1 billion for the DOD reimbursements for payments through FY 1987 (flights through FY 1988), consistent with the original agreements provision for fixing the payments of $12.2 million (FY 1975 dollars) per launch for the first six years of Shuttle operations. The DOD estimate continued the $12.2 million pricing through launches in the seventh year (FY 1989), for which payment would be made in FY 1988. In addition, the DOD estimate also includes the estimated cost of standard range support services which the revised pricing agreement stipulates will be funded by the DOD.

The DOD estimates are consistent with NASA's calculations based on the DOD flight rate projection.

Question 22: Why did NASA decide to establish a three-year fixed price (FY 1986-1988) for commercial and foreign users rather than adjust the price annually as initially planned?

Answer 22: The NASA pricing policy was set for launches in FY 1986-1988 (instead of just for FY 1986) to remove customers concerns in recognition of the long lead commitments and planning required by customers in their procurement and operation of payloads.

Question 23: What is the basis upon which NASA established a $38 million (FY 1975 dollars) commercial launch price, (i.e., out-of-pocket costs, average cost, price competitive with ELV launches, etc.)?

Answer 23: The NASA pricing policy for launches in FY 1986-1988 is based on the estimated average out-of-pocket costs over that three year period that is the cost incurred over that required to support U.S. Government missions. Under this policy, the additional costs of the flights purchased by foreign and commercial customers would be fully recovered, assuming projections of learning curves and cost improvements are realized, (i.e. there would be no additional burden to the taxpayer, and there would be, in fact, a contribution to NASA's fixed costs). The $38 million (FY 1975 dollars) price is somewhat less than prices for foreign ELV launches and a fraction of USG ELV launch costs.

SPACE TECHNOLOGY CENTER

Question 24: DOD has just created a new Space

Technology Center at Kirtland Air Force Base in New Mexico to "focus on the major scientific disciplines for launch vehicle and spacecraft technology."

How will this realignment affect the dependence of DOD on work which is conducted in the NASA centers? In other words, is the Space Technology Center a step toward a DOD capability which is parallel to or independent of existing NASA capabilities?

Answer 24: No. The Air Force Space Technology Center was formed to provide a focus for the existing space related laboratories within the Air Force. Three long established laboratories, the Geophysics Laboratory, the Rocket Propulsion Laboratory, and the Air Force Weapons Laboratory, are all under the Space Technology Center. This new management organization will facilitate coordination between Air Force Research and Development efforts which have been and will continue to be devoted to military requirements. The Space Technology Center in no way parallels existing NASA capabilities. We have a long history of NASA/Air Force cooperation in aeronautical and space technology and we expect that cooperation to continue in the future.

CONSOLIDATED SPACE OPERATIONS CENTER

Question 25: If the Consolidated Space Operations Center (CSOC) is not completed on schedule in 1987, can DOD turn to Johnson Space Center (JSC) for launch operation controls? How would the NASA launch schedule be affected in accommodating the DOD operations? Have contingency plans been made by NASA and DOD?

Answer 25: The CSOC is scheduled to become operational as a Shuttle control element incrementally beginning with the flight planning capability in 1987. The CSOC will become capable of controlling Shuttle on-orbit operations in 1989-1990. Each increment will remove some of the work load from JSC. The baseline JSC capability is sufficient to handle DOD requirements during the transition to CSOC without impact to NASA. Since we are now lead time away from the transition, we are formulating contingency plans. In general, to cope with a delayed CSOC, those plans will address some combination of the following:

--Increased JSC capability

--Decreased civil/commercial/foreign traffic

--Decreased DOD traffic

--Reduced or temporarily relaxed DOD security requirements. Those plans must also consider the plans now being formulated for JSC modernization (an FY 1985 NASA budget issue) which are also key to CSOC planning.

SPACE SCIENCE AND APPLICATIONS

Question 26: The Research and Analysis programs provide funding for many universities and research groups to fully utilize data from many of our planetary missions, experiments, and astronomical projects. These universities and research groups say that this data is underutilized due to the declining Research and Analysis budgets since FY 1981. What basis is there for the overall decline in the Research and Analysis budgets for FY 1984?

Answer 26: The total Space Science and Applications FY 1984 Research and Analysis budget has actually increased by approximately 14 percent over FY 1983.

ADVANCED X-RAY ASTRONOMICAL FACILITY

Question 27: It has been understood that NASA would release an Instrumentation Announcement of Opportunity on March 1, 1983, and an Industry Request for Proposals (RFP) on February 1, 1983. What is the status of both of these documents?

Answer 27: The question does not address what program it is referring to; however, an Announcement of Opportunity (AO) for the Advanced X-Ray Astronomical Facility (AXAF) is presently being developed in preparation for release in mid-1983. A Request for Proposals has not yet been developed.

Question 28: If, in fact, Perkin Elmer is already under contract and working on development of the necessary mirror technology for AXAF, is there any reason to think that the problems associated with the Space Telescope will affect the plans for AXAF?

Answer 28: Perkin Elmer and ITEK Corporation are both presently under contract to conduct definition studies on the x-ray mirror construction and reflectivity. Since there are no definite plans for initiation of AXAF design and development activities, we do not anticipate that the Space Telescope problems will affect the present AXAF studies at Perkin Elmer.

SPACE TELESCOPE

Question 29: The Space Telescope has encountered some technical and managerial problems. What cost and schedule overruns are now anticipated and how are your FY 1983, FY 1984, and FY 1985 program plans and budgets affected?

Answer 29: A review is currently in process to determine the cost and schedule impact of the current Space Telescope technical problems. This review has not yet been completed; therefore, we do not know what effect these problems will have on the current funding levels in FY 1983 and FY 1984 or the cost through completion.

Question 30: What is the expected launch date of the Space Telescope compared to the original launch date of early 1985?

Answer 30: NASA will not know the schedule impact of the current Space Telescope technical problems under a review, which is currently in process, has been completed. It is anticipated that this review will be completed by the May/June 1983 timeframe.

Question 31: What lessons has NASA learned from this experience? Are any management changes anticipated which would prevent similar problems from occurring in other NASA projects?

Answer 31: Because NASA is a research and development Agency, it is imperative that technical challenges will be encountered in the future because each project is a unique challenge, and NASA recognized from the outset that the Space Telescope design and development activities would a technical challenge. Therefore, it is not evident whether the current Space Telescope problems could have been prevented, or exactly how much, if any, of the Space Telescope development experience can be applied to other NASA projects. NASA has always tried to make sure that high management standards are maintained on all projects and programs.

Question 32: How will Perkin Elmer's problems with the optical telescope assembly of the Space Telescope affect Lockheed's budget and schedule?

Answer 32: The Lockheed effort in the overall integration of the Space Telescope is keyed to the delivery of the optical telescope assembly by Perkin Elmer. Any slip in the delivery of the optical telescope assembly will cause a slip in Lockheed's activities and the ultimate launch date. However, until the review, which is currently in process, is completed, the exact amount of impact on Lockheed's activities and the launch will not be known.

Question 33: In December 1980 NASA increased its cost estimate for developing the Space Telescope to $725 - $775 million, which is still the current estimate. It included a reserve of $194.8 million. The estimated cost for known requirements to complete the telescope was $337.7 million. As additional requirements become firm, the reserves are reduced and the estimated cost for known requirements is increased. The status of the reserves and requirements are shown below. (All dollar amounts are in 1984 dollars.)

Status	Unencumbered reserves for development					
as of	FY80	FY81	FY82	FY83	FY84	FY85	Total
			(millions)				
Dec. 80	0.3	8.1	21.2	68.7	44.2	52.3	$194.8
July 82	-	-	1.4	16.1	22.0	39.3	78.8
Currently							

Status	Estimated cost of known requirements to complete development					
as of	FY81	FY82	FY83	FY84	FY85	Total
			(millions)			
Dec. 80	$111.2	$98.3	$68.4	$46.0	$13.8	$337.7
July 82	-	a/ 3.7	120.2	66.4	22.7	213.0
Currently						

a/This is the estimated cost for August and September 1982 only.

a. What is the current amount of the Space Telescope reserves?

b. Between December 1980 and July 1982, NASA used reserves at a rate of about $5.86 million a month. If this rate were to continue, the reserves would be eliminated by August 1983. Based on this information, what confidence does NASA have that it can complete the development program within the current estimate of $775 million?

c. In both fiscal years 1981 and 1982, NASA deferred work which was scheduled to be done during those years to succeeding years because of funding problems. From December 1980 until July 1982, the cost of work scheduled to be done in FY 1983 increased from $68.4 million to $120.2 million, an increase of 76 percent. What is the current estimated cost of known requirements for fiscal years 1983 through program completion? What is the likelihood that work currently planned to be accomplished in FY 1983 will have to be deferred until future years?

Answer 33:

a. As of October 1982, there was $56 million of unencumbered reserve in the Space Telescope program. Since that time, technical and management problems have caused NASA to reassess the Space Telescope program and its reserve status. We are currently reviewing a range of alternatives for rephasing the work to minimize the cost and schedule impact. As soon as our evaluation is complete, we will inform the committee of our proposed actions.

b. As might be expected in a program of this complexity, we are continuing to experience technical problems, particularly in the optical telescope assembly development activities, which will most likely impact the scheduled launch commitment of the first half of 1985 and runout cost of $725-$775 million (FY 1983 dollars) for the Space Telescope.

c. As a result of the difficulties we have recently uncovered in the development of the optical telescope assembly, there is a strong likelihood that we will not only revise the total cost of the program but we will also need to reprogram funding in FY 1983 and FY 1984 to meet the required needs of this project. We anticipate that additional funding will be obtained from existing NASA resources in FY 1983 and within the budget totals proposed in the FY 1984 budget.

Question 34: Since this highly skilled work force contributes significantly to the accomplishment of the programs, it is important to review the two budgets together in order to understand the status of the program. Since the inception of the Space Telescope program, several efforts which were originally planned to be accomplished in-house by the civil service work force. In a sense, this represents a cost growth in the program.

a. Please provide a listing of all tasks which were originally planned to be accomplished by the contractors but were subsequently deleted from the contracts and are now being accomplished in-house.

b. What is the estimated value of this work?

Answer 34: a. Following are tasks that were originally planned to be performed by the associate contractors that are now being performed in-house, or by other contractors under the direction of the project:

--Optical telescope assembly fracture mechanics analyses (in-house)

--Design and development of installation equipment for scientific instruments and fine guidance sensors (design in-house, manufacturing contractor)

--Optical telescope assembly shipping container design and development (contractor)

--Space support equipment design and development (design in-house, manufacturing contractor)

--Space Telescope simulator for Space Telescope operations control center training (in-house)

--Orbital verification planning (in-house)

b. The estimated value of this work is approximately $40 million, including cost of material and subcontracted effort.

Question 35: When the Space Telescope program was revised in late 1980, the program was descoped to a higher risk program. For example, spares which would have been available to replace components which fail during the assembly and verification phase were eliminated from the program. In addition, a number of subsystem tests were deleted.

a. How would NASA characterize the additional program risk associated with the descoping?

b. Since spares were deleted, how will the Agency respond to a component or subsystem failure which occurs during the final assembly and verification phase? If a failure should occur, will it mean that the Space Telescope launch will be delayed more than would have been necessary if the spares originally planned had been available?

c. Does the reduction in subsystem testing mean that the overall Space Telescope test program is more risky?

Answer 35:

a. The descoping effort will impact our ability to respond to equipment failure during subsystem and system level verification and testing. For example, if during this testing we experience an anomaly in a black box for which we have no flight spare, we will be forced to repair the box rather than replace it with the spare. This may add time to our test schedules. In order to minimize the impact of possible failures, we have retained flight spares for some of the most critical equipment and we feel that the additional risk introduced by this reduction in our spares program is acceptable.

b. Spares for many components and subsystems have been maintained, especially for those items such as rate gyros, reaction wheels, and batteries, which would require long lead time to repair or replace in a timely fashion. Complete replacement parts, assembled to the electronic board level, exist for many other components and subsystems. If a failure should occur for these components and subsystems, it will probably require more time and effort to correct than if a completely assembled spare were available. In most instances, however, workarounds and test procedure adjustments can be instituted to minimize or prevent significant delay in the Space Telescope launch schedule.

c. A major purpose of subsystem testing is to weed out hardware and software problems prior to system level testing. The deferral of testing from the subsystem to the system level means that some problems will surface later in the program. Consequently, the risk associated with reduced subsystem testing is the increased time and resources required to correct these problems during system level tests. In either case, the successful completion of system testing will provide confidence to proceed to the launch.

Question 36: Whereas, in the past, it has been necessary to design satellites with components of an extremely high reliability and to frequently build in redundancy to preclude satellite failures, the unique capabilities of the Space Shuttle which enable in-orbit repair and, if necessary, the return of the telescope to earth, permit NASA to relax reliability and redundancy requirements.

a. To what extent has the Agency taken advantage of these unique Shuttle capabilities in designing the Space Telescope?

Answer 36:

a. NASA has taken full advantage of the Shuttle's unique capabilities in the Space Telescope design and development. The Shuttle will be used to ferry the Space Telescope to orbit and to conduct in-orbit checkout prior to deployment. The Space Telescope is designed to be serviceable in-orbit by space-suited astronauts during Shuttle revisits. In the event that a problem cannot be solved by in-orbit maintenance, the Space Telescope is designed to allow retrieval and return to earth by the Shuttle for ground maintenance and/or refurbishment and subsequent relaunch.

Question 37: When NASA revised the Space Telescope program in late 1980, the Agency established a target launch date of the first half of calendar year 1985. Internally, however, the project office established a goal of launching in November 1984. Contract schedules were structured to meet the November 1984 launch date. In effect, the overall launch schedule contained a seven-month reserve (November 1984 - June 1985). By August 1982, the project office had revised its launch goal to January 1985 because of continued technical problems and funding constraints.

What is the probability of meeting the project office goal of launching the Space Telescope in January 1985?

Answer 37: The difficulties encountered in the development of the optical telescope assembly have caused the project office to abandon the goal of launching the Space Telescope in January of 1985. The project office is currently developing a number of alternatives to rephase the Space Telescope development efforts and to determine the impact on the launch schedule. As soon as our evaluation is complete, we will inform the committee.

Question 38: When the Space Telescope contracts were awarded, "bake-out" of structural components was not included as a requirement. Space Telescope structures are significantly larger than those of any previous orbiting telescope and only a few facilities in the United States are capable of performing a "bake-out" of components the size of those planned for the Space Telescope. The time required to perform the "bake-out" together with the equipment needed to clean the facilities and perform the "bake-out" would be very expensive. Since no data were available on the effects of not performing the "bake-outs", the contracts required only that the components be "visibly clean." Subsequent testing and analyses have shown, however, that meeting the "visibly clean" requirement will not be adequate. Molecular contamination would degrade Space Telescope optics to an unacceptable degree.

a. In October 1981, the Space Telescope Science Working Group established specific contamination control criteria which they said were essential to achieving the scientific objectives of the telescope. Has NASA now accepted these criteria and incorporated them into the telescope development contracts?

b. What is the estimated cost and schedule impact of meeting the contamination control criteria established by the Science Working Group?

c. The Science Working Group has described its criteria as being consistent with the minimum performance requirements of the telescope. If NASA has not accepted the contamination control criteria established by the Science Working Group, what level of contamination control does the Agency plan to require? What is the estimated cost and schedule impact of this requirement? What is the extent of performance loss which will result from not meeting the criteria established by the Science Working Group.

Answer 38: The Science Working Group contamination criteria were analyzed by a joint NASA/Lockheed Missile and Space Corporation/Perkin-

Elmer technical review team to determine what steps must be taken by the Space Telescope project. It was determined from this review that the major concern will be molecular contamination. It was also determined from this review that all large structural assemblies such as the main ring, main baffle, secondary mirror assembly, reaction plate, aft shroud, forward shroud and sun shade must be "baked-out," in a vacuum chamber, in order to meet the working group criteria. Additionally, clean room molecular contamination monitoring and procedural controls are needed to maintain hardware cleanliness.

All of the above hardware "bake outs" and clean room improvement are currently being implemented. Remaining actions concerning the focal plane structure and the support system module equipment section are presently under review. Tests and analyses are being conducted to determine whether or not "bake out" of these items is required in addition to contamination control measures which have already been adopted.

b. The cost of the molecular contamination control program is estimated at $2.5 million with no projected schedule impact. Additional cost, to be determined, will be incurred if "bake out" of the focal plane structure and the support systems module equipment section are required. Bake out of the focal plane structure, if required, will probably impact the optical telescope assembly schedule.

c. The project has implemented the steps required to meet the Science Working Group criteria as stated above, and no additional performance loss is anticipated.

MAINTENANCE OF QUALITY PERSONNEL AT NASA

Question 39: It has been suggested that one of the best ways to meet the challenge of foreign competition that is subsidized by the respective country of that competitor, is through maintaining and expanding our technological and scientific edge. Also, there is now a concern that NASA's manpower resources are not what they were several years ago, partly due to the loss of critical personnel to private industry. What is NASA doing to attract to make "new blood" to the Agency? What is NASA doing to make the Agency attractive enough to keep personnel from leaving for the private industry?

Answer 39: The loss of our scientists and engineers (S&E) to the private sector has risen slightly in the past few years from about 75 per year in 1979 to 100 per year in 1981 and 1982. Even though there has been some increase in the number and rate that S&E's are leaving NASA for the private sector, such separations account for only about 20 percent of S&E turnover and are less than one percent of the total S&E work force. We do not believe that losses to the private sector are a critical factor to our S&E work force excellence.

The fact that we now foresee a level overall ceiling at least through 1984, if not beyond, will help us solve many of our technical work force problems. It means that we will be able to replace all the S&E's who do leave with "new blood", which should take care of whatever revitalization we need.

In 1983, the Agency is placing great emphasis on the hiring of new college "fresh-out" scientists and engineers. We hope that we will be able to hire over 350 "fresh-outs" this year and 450 next year. These goals compare to an actual hiring of only approximately 250 last year.

We believe that the main attraction of NASA is the exciting technical work we are doing in space and aeronautics, much of which is, as it always has been, on the "cutting edge" of technology. We complement this with extensive and comprehensive training and development programs for all levels within the Agency. We hope that this continuation of exciting work and opportunity for professional development and growth will be sufficient to maintain a healthy, vigorous technical work force.

Table A

1/24/83

OFFICE OF SPACE FLIGHT

LAUNCH VEHICLE INVENTORY

As of 31 December 1982

	Ordered Thru FY82	To Be Delivered	Launched Thru 31 Dec. 82	Inventory 31 Dec . 82	FY83 To Be Ordered	FY84 Plan
SCOUT	117 a/	-0-	102	15	-0-	-0-
THORS FOR DELTA	184 c/	6	165	7	-0-	-0-
DELTA	184 c/	6	165	7	-0-	-0-
ATLAS-DIA	69 b/	7	60	1	-0-	-0-
TITAN-IIIE	7	-0-	7	-0-	-0-	-0-
CENTAUR	75	7	67	1	-0-	-0-
ATLAS-F	11	4	5	2	-0-	-0-

a/ INCLUDES NINE DEVELOPMENT VEHICLES AND FOUR SEPARATE DOD/AF PROCURED VEHICLES.

b/ INCLUDES REPLACEMENT BOOSTER FOR ATLAS CENTAUR 33. ATLAS TANK REQUIRED REPLACEMENT BECAUSE OF BAD WELDS.

c/ TERMINATION ACTION PENDING FOR VEHICLES 179-184.

Questions submitted by Senator Heflin from the March 9, 1983, hearing

SPACE TRANSPORTATION SYSTEM

Question 1: What effect will slippage of the Shuttle's sixth flight have on subsequent missions and specifically the Spacelab mission scheduled this fall which is so important to the European community?

Answer 1: The delay of the STS-6 launch to April 4, 1983, will delay both STS-7 and STS-8 until about mid-June and early August, respectively. NASA's optimistic plan anticipates that there will be no delay in Spacelab-1 (STS-9) as it is being launched on the Columbia. However, the delay in the second TDRS launch (STS-8) increases the probability that the second TDRS will not be sufficiently checked out and in position to support the Spacelab-1 mission. Therefore, contingency mission plans are underway to evaluate the acceptability of a Spacelab mission supported by a single TDRS spacecraft. The decision on acceptability from a science viewpoint is based on having a timeline which satisfactorily minimizes the loss of scientific data.

Question 2: NASA intends to purchase additional Shuttle spares investing $100 million in FY 1984 and another $300 million in future years. This approach presumably will keep open the option to purchase a fifth orbiter. Rockwell has provided the Committee staff with an analysis which suggests that an additional $70 million investment in spares in FY 1984 would significantly minimize the eventual cost of a fifth orbiter. If the country ultimately moves forward with a fifth orbiter, do you believe it would be prudent to invest the additional amount this year?

Answer 2: The $100 million (as part of a $420 million structural spares program) requested by the Administration to support orbiter structural spares procurement preserves these major subcontractors through mid 1986. It also preserves other structural elements and critical component subcontractors through early 1986.

NASA's position is that the $100 million FY 1984 funding level is sufficient to retain a reasonable level of orbiter production capability in case a decision is made at a later date to procure a fifth orbiter.

The Rockwell position is that the addition of $70 million would enhance that retention capability somewhat and perhaps enable a fifth orbiter to be delivered slightly earlier. However, the need for a fifth orbiter is not conclusive based on the current flight rate projections for firm missions in the late 1980's. Given the magnitude of the additional investment --

approximately $1.5 billion on top of the $.4 billion -- required for delivery of a fifth orbiter in 1989, it appears prudent to establish the real need. In the meantime, the President's decision to acquire the structural spares to protect against an extended loss from service of an orbiter is an appropriate course of action.

Question 3: The Space Transportation Company has proposed to have the private sector purchase a fifth orbiter in exchange for certain marketing rights. Do you believe that under the right set of conditions private sector investment in a fifth orbiter would be in the national interest? What might those conditions be?

Answer 3: It could be that under the right set of conditions, private sector investment in the Space Transportation System (STS), including the purchase of orbiters, is in the national interest. Among those conditions that we would propose to include would be:

--Any agreement between the Government and a private sector proposer to purchase an orbiter must provide under fair reimbursement for the Government to exercise under extraordinary conditions its priority for national security and rescue or NASA priority missions.

--The prime requirement of the national STS is to have a safe system, and the private sector proposer would have to agree to an orbiter configuration which satisfies that requirement.

--An agreement between the Government and a private sector proposer for the purchase of an orbiter cannot be exclusive, without competition, or must maintain an option for other interested parties to participate on a similar or equal basis, and,

--Any final agreement between the Government and a private sector proposer for the purchase of an orbiter must be a public agreement, which is demonstrably in the Government's interest as well as meeting the legitimate needs of the proposer.

Question 4: In its annual report, the NASA Aerospace Safety Advisory Panel (ASAP) provides some recommendations on effective technical development and operation of the Shuttle. Among the key areas they provide recommendations on the Shuttle's turbopumps and the Shuttle's landing gears and brakes. What steps is NASA taking to implement the Committee's report?

Answer 4: We are currently in the process of assessing each recommendation of the Aerospace Safety Advisory Panel and we have not formulated final responses to the recommendations. However, our current program plan includes activities which address many of the items in the ASAP report.

The SSME Program Plan for FY 1984 includes a small initial investment for SSME life improvements and engineering redesigns of critical life - limiting components of the engine. The turbomachinery identified in the ASAP report is one of the planned areas of redesign activity for FY 1984. The initial funding for this redesign effort is at a level of $4 million for FY 1984.

The landing gear tires and brakes as originally designed were marginal especially in light of the increased orbiter landing weights, particularly the abort landing weights, and under worse case crosswind conditions. Improvements have been incorporated in the original design. The main tire ply rating was increased from 28 to 34 and a spacer has been added to prevent axle deflections from damaging the brakes. Protective steel covers are planned for the brake rotor lugs prior to STS-7.

The improvements were designed to remove the landing gear from the marginal category. Tests and analyses are now being conducted to verify the gains these improvements offer for maximum proposed landing loads. Should the tests and analyses indicate the need, further improvements will be made as required.

Question 5: Since the decision last year to develop Centaur for two planetary missions only, are you initiating definition studies for the follow-on orbital transfer vehicle (OTV) to be available in the early 1990's for additional missions not currently attainable with the Centaur?

Answer 5: Yes, we expect to initiate parallel, competitive "Phase A" studies of the OTV by FY 1984. Marshall Space Flight Center (MSFC) is preparing a Request for Proposal at this time.

The studies will explore the configuration, performance, utility and cost of an OTV that is placed behind the Shuttle's external tank to enable the orbiter to accommodate payloads (or combinations of payloads) up to 60 feet long. Consideration will be given to the potential to evolve such a vehicle for basing at a space station.

Question 6: One of the important directions for the U.S. space program to take is to find more ways to have the private sector contribute and make investments in space-related ventures. We've seen a number of private sector initiatives in the past year or so, including:

--purchase of a fifth orbiter

--development of a space station

--development of high energy upper stags for the Shuttle

--production or private launch services, and

--purchase of NASA's expendable launch vehicles.

What is the Administration's policy on such ventures, and what is NASA doing specifically to analyze the opportunities and barriers to space commercialization?

Answer 6: The National Space Policy announced by President Reagan on July 4, 1982, establishes an objective of increasing private sector investment and involvement in space activities. In order to accomplish this objective, NASA has commissioned a study of the opportunities and barriers to commercial activities in space. This study is being conducted by the National Academy of Public Administration. At the same time, a subcommittee on the NASA Advisory Committee is reviewing specific activities which can lead to increased commercial utilization of the Space Transportation System. These efforts are expected to provide the appropriate guidance for NASA in the accomplishment of the stated policy objective.

Question 7: Last year the Commerce Committee reviewed NASA's pricing policy for Shuttle flights and in particular the prices established for DOD missions. The GAO also reviewed this matter. In your statement, Mr. Beggs, you referred to the revised DOD/NASA pricing policy which would result in a DOD reimbursement to NASA of about $1.0 billion more than had been negotiated in the previous agreement. In the Conference Committee report last fall, the Congress directed NASA to seek "fair value" in its pricing policy.

a. Do you believe the new pricing policy represents "fair value" to NASA?

b. Last fall the DOD indicated they would contribute an estimated $60-90 million to NASA for Shuttle spares. Has this transfer of funds occurred?

Answer 7:

a. Yes. The NASA/DOD Memorandum of Understanding (MOU) which establishes prices for DOD missions is fair based on the recognition of the DOD's extensive investment in the STS, their role in operating the Vandenberg Launch Site, and the organic capability furnished by each agency to support launches. Accordingly, the NASA flight charges are based on anticipated full cost recovery for material and service charges. Other provisions of the MOU concentrate on minimizing the impact of DOD unique national security requirements on the overall operations of the STS.

b. The Department of Defense has no funds currently identified explicitly for orbiter spares. Under both the prior and the recently negotiated agreements between NASA and the DOD for Shuttle flight charge reimbursement, orbiter spares are a NASA funding responsibility and flight replacement spares are an element of cost included in the reimbursable charge per flight.

SPACE SCIENCE AND APPLICATIONS

Question 8: Mr. Beggs, I am pleased that NASA will be proceeding with the Advanced Communications Technology Satellite (ACTS) program that the Congress wanted.

--Would you explain the nature of the industry participation in this program?

--Also, will you tell the Committee what impact the new fiber optics technology will have on satellite communications?

Answer 8: On March 3, we released a Request for Proposals to develop and operate an experimental ACTS payload for two years in geostationery orbit. The contractor would be required to develop and operate a set of ground terminal equipment required to command and track the satellite and manage the experiments. We expect industry to share risks in this program in two ways.

First, we have structured the procurement such that we allow the contractor the flexibility to be innovative in his proposal. For example, he might propose to use a spacecraft bus of his choice and provide the bus at some cost savings to the Government. The contractor might propose to add other payloads (either experimental or commercial) to the bus. We have offered the contractor the option (for consideration) to acquire the assets of the program at the end of the two year period to earn revenue or continue experimenting. By providing this flexibility, we have included both the opportunity and the incentive for cost sharing by the manufacturing industry, in order to minimize the size of the Government's investment.

Second, we have allowed for cost sharing by other segments of the communication industry by offering them an opportunity to experiment with this advanced technology system if they pay for their own ground terminals and data reduction. This approach was used successfully on Communications Technology Satellite

(CTS) and we expect to see significant cost sharing investments in ACTS.

The impact of fiber optics on satellite communications has been thoroughly considered in all of NASA's past and present market analyses, and the advances in fiber optics technology and applications come as no surprise. The satellite communications demand forecast which points to the need for spectrum expansion and conservation has taken these advances into consideration. Increased use of fiber optics will impact the demand for communication satellite systems both as a competitor and a catalyst. Satellites and fiber optics will compete for long-haul wideband/trunking point-to-point links with market shares determined by comparative costs. The use of fiber in wideband local loops connected to satellite wide area distribution networks will have a synergistic effect, increasing the markets for both media as well as the total communications market, in general.

Question 9: NASA had requested $39.2 million from OMB for the communications program but received only $21.1 million. Other than the ACTS program mentioned above, what does NASA's communications program consist of? Do you believe NASA could be doing more high risk technology development work that would be of economic importance?

Answer 9: In addition to the ACTS, our communication program consists of the following:

--Search and rescue program which locates aircraft and vessels in distress.

--Mobile communications studies, which is a joint activity with Canada to explore technology to allow expansion of mobile telephoning, paging, and data collection into rural areas by means of satellite communications.

--Experiment coordination and mission support activities which are designed to fulfill our public service obligations.

--Technical consultation and support activities which are designed to support the U.S. positions in the upcoming World Administrative Radio Conferences (Warcs) and Regional Administrative Radio Conferencees (Rarcs).

--Research and analysis activities which have concentrated on component and device technology development in support of the ACTS program.

We are also conducting early definition activities on potential programs associated with efficient spectrum and power utilization, systems networking and architecture, ground terminals, intersatellite links, and geosynchronous platforms that have significant potential economic benefits.

Question 10: NASA requested $4 million from OMB to support its efforts in AgRISTARS, a multiagency program to improve our ability in agricultural crop forecasting. The OMB did not allow a penny. What effect will this decision have? Will other agencies pick up the effort?

Answer 10: The NASA AgRISTARS activity was a research and development program to develop new techniques for applying remote sensing data to USDA information needs. The AgRISTARS technology transfer function was USDA's responsibility and it will be continued. The other participating agencies, including NOAA and AID, are continuing their elements of the program, and NASA will be available to support these agencies on a reimbursable basis.

Question 11: NASA is proposing to do an increased amount of research on the effects of weightlessness on our astronauts. I understand that space motion sickness seems to be fairly common on the Shuttle flights. Do we know what causes space motion sickness? Have we learned anything from the Russians in this area?

Answer 11: Neither we nor the Soviets know the specific cause of space motion sickness. The symptoms have occurred in varying degrees during the first few days of flight for about half of the crew members who have flown. The problem appears to be associated with a dysfunction of the vestibular system of the inner ear that normally establishes an individual's reference by sensing the gravity vector. Some drugs seem to be partially effective but have some side effects. With the opportunity of performing physiological experiments on-board the Shuttle, we plan to focus more effort on potential specific solutions involving new drugs, psychological techniques, programmed adaptation, and head restraining devices.

The Soviets continue to suffer from the same problem; however, they have been flying longer flights and have found that by keeping their crews inactive for the first few days they are able to adapt.

Question 12: The Members of this Committee have been getting mail about the role of animals in NASA's life sciences testing program. What guidelines does NASA follow to make sure that this research is conducted in a humane manner?

Answer 12: NASA follows the policy that research using laboratory animals will be conducted only at institutions that comply with the Laboratory Animal Welfare Act as amended in 1976; that follow NIH guidelines for the care and protection of animals; that have special Animal Care and Use Committees to oversee all animal research; and, if possible comply with the standards of the American Association for Accreditation of Laboratory Animal Care. Included in this policy is the requirement that anyone responsible for the care and treatment of animals be a trained professional. With regard to experiments involving space-borne animals, only certified veterinarians, physicians or physiologists will be permitted to participate.

Question 13: At the international UNISPACE Conference held in Vienna last year, the U.S. Government proposed a global habitability study that could involve all Nations. What is the status of that effort, and what funds are provided in the NASA budget?

Answer 13: The global habitability concept was initially proposed to delineate current NASA capabilities on the understanding of global processes and to provide a focus for a NASA earth sciences program. The concept was based on the growing scientific awareness that significant advances in the earth sciences in the next decade would only come about as the result of a multidisciplinary research effort.

The overall concept envisioned a large effort to which NASA would contribute only part, and thus required the participation of other U.S. agencies, other governments, and the scientific community.

Since UNISPACE, NASA has proceeded on three fronts:

--A global habitability planning effort has been established. Detailed science plans are being prepared in the areas of global biology, land resources, and atmospheric and ocean processes as related to biogeochemical cycles.

--Preliminary discussions on collaboration and coordination of programs have begun with USDA, NOAA, and NSF. NASA has recently initiated discussions with officials within the National Academy of Sciences/National Research Council. We feel that the Academy can play a vital role in further defining the global habitability concept and in providing a vehicle around which to aggregate the U.S. effort. The National Academy of Sciences is the primary U.S. interface with international scientific organizations.

--NASA has held informal discussions with some interested international organizations (e.g. United Nations Environment Program, Joint Science Committee of the World Meteorological Organization, Food and Agricultural Organization), but no formal arrangements will be made until a U.S. program has been defined.

As stated earlier, the global habitability concept provides a focus for the NASA earth sciences activities. Much of the present funding within the Solid Earth Observations and Environmental Observations portions of the Space Applications budget line item is being applied to tasks and missions that are directly relevant to this focus.

Question 14: You indicate that NASA has experienced some technical difficulties with the Space Telescope project. This project is a high priority one for the scientific community, NASA and the Congress. Do you believe the technical problems can be worked out? What do you estimate will be the cost and schedule impact of the technical problems?

Answer 14: The Space Telescope continues to be a complex and technically challenging endeavor. Although we have encountered some serious difficulties in our development efforts, we believe we will be able to solve these difficulties. None of the problems which we have encountered require technology breakthroughs, and we believe they can be solved with some extremely detailed and precise engineering and manufacturing work and meticulous assembly procedures. We are currently conducting a review to determine the schedule and cost impact of these problems. Our best guess, at the present time, is a slip of at least one year and a cost growth of at least $200 million.

Question 15: The Space Science Working Group, a group of university scientists, have supported NASA's space science efforts generally. They have also recommended an increase in various Research and Analysis line items totalling $17 million. Do you agree with the Group's recommendations?

Answer 15: We believe that the Research and Analysis funding requested in the FY 1984 budget is adequate to support the highest priority items in our program, consistent with the need for fiscal restraint in support of the President's economic recovery program.

TECHNOLOGY UTILIZATION

Question 16: Once again the OMB has cut back NASA's Technology Utilization program from $10 million to $4 million. This program has been highly successful in applying NASA technology to non-space commercial markets. Benefit-cost studies show about a $6 return for every $1 invested. Why does OMB take such a negative view of this program?

Answer 16: The Office of Management and Budget (OMB) has taken the view that considerable aerospace technology is already available in the private sector through NASA contracts. Therefore, OMB has taken the position that the Technology Utilization program has low priority in comparison with other agency programs.

AERONAUTICS AND SPACE TECHNOLOGY

Question 17: During both sessions of the 97th Congress, its determination to see your Agency carry out specified systems technology programs was made clear by its augmentation of your budget requests and by its clarification in Conference Committee reports of the programs for which that augmentation was provided. Can you explain, therefore, why your FY 1984 budget request provides no funding for several of those programs, notably the advanced turboprop, active laminar flow control, general and commuter aviation technology, and aircraft energy efficient programs for subsonic transports and engines?

Answer 17: NASA initiated these programs because of our belief that the potential technology advances could be of great value to both civil and military aeronautics. Progress in the research thus far has been very encouraging and has only strengthened our original convictions. We are making effective use of the additional funds provided by the Congress in FY 1983 to further the research efforts.

The overall aeronautics program requires a balance of activities ranging from fundamental research and continuing improvement of research capabilities to full-scale flight testing. By necessity, the more costly systems technology programs involving full-scale hardware investigations are planned as augmentations to the fundamental research effort which must be maintained if we are to fulfill our obligation to serve as the country's primary aeronautical Research and Technology resource. When budget constraints prevent adequate systems technology augmentations, it becomes difficult to maintain the pace of desired progress without seriously impacting the more fundamental research effort. As a result, the systems augmentations are generally deferred unless they are of great national urgency. Inasmuch as these major systems programs are typically 5-10 year efforts, the infusion of additional funds on a one-time basis - although a positive step--cannot solve the longer term problem. Continuing progress is being made in the discipline related to each area, and follow-on augmented efforts are planned, but the current budget does not permit the level of augmentations needed to sustain these larger-scale activities.

Question 18: Your statement this morning points out quite correctly that the joint service JVX vertical takeoff and landing aircraft program is made possible by flight research of the XV-15 tilt rotor proof-of-concept program. Why, therefore, is your Agency unable or unwilling to recognize that the civil aviation industry's ability to bring forth the prop fan propulsion system likewise depends upon NASA's completion of a comparable proof-of-concept flight, research program as urged by the Congress?

Answer 18: NASA does recognize the importance of flight testing in the development of advanced turboprop technology for both civil and military applications. The required flight testing is not a proof-of-concept activity, but rather a research program to investigate problem areas which can only be addressed in flight--e.g., propeller structural dynamics and cabin noise control. Together with the planned ground-based research, it would provide the data base essential to turboprop design and development.

NASA's Advanced Turboprop Program plans have consistently included flight research, shown as a new phase starting in FY 1985, supporting the required long lead preparations for flight experimentation beginning in 1987. The omission of turboprop funding in the FY 1984 program will result in slower-paced preparations and possible delay of the flight experiments.

Question 19: You mentioned research emphasis on commuter aircraft technology. Can you tell me more about what that entails, particularly whether it will contribute anything to our general aviation industry's position in the world commuter aircraft market which is dominated by foreign manufacturers?

Answer 19: Since 1978 when the U.S. Senate Committee on Commerce, Science and Transportation requested that we address this important matter, NASA has investigated the opportunities for technological improvements in small transport aircraft for regional (formerly commuter) airline service. As a result, we have taken steps to ensure that our aeronautics program objectives and activities will help make it possible for U.S. industry to improve its competitive position in world markets through the design of superior next generation aircraft of this type.

Studies conducted by NASA and by industry under NASA contract between 1978 and 1982 clearly showed the improvements in performance, comfort, equipment cost and cost of operation possible for future designs of small transport aircraft in the 20 to 50 passenger field. These improvements were based first on making maximum use of available technology in aerodynamics, structures, controls and propulsion systems in relatively conventional aircraft configurations, but eventually on utilizing emerging technological advances (some of which are not yet available) in aerodynamics, structural materials and propulsion. Improvements which could be achieved include up to 40 percent greater fuel economy and 24 percent reduced operating costs, together with significantly quieter interiors and greater passenger comfort through improved ride qualities. A preliminary report on NASA's initial findings was submitted to the Senate at the end of 1979, and a report summarizing subsequent advanced technology system studies was provided in late 1982.

A large percentage of NASA's aeronautics research and technology program was found to be directly or indirectly applicable to the design of future small transport aircraft, particularly in the areas of aerodynamics (including natural laminar flow technology), composite materials and structures, and advanced propellers. It should be noted that most promising new aircraft designs in this field would be propeller driven, not turbofan, since propeller propulsion more advantageously matches the mission profiles of expected regional transport aircraft. In other areas of technology, such as aerodynamic configuration research, engine research in the power ranges of interest, and in propulsion integration for promising and unusual configurations, we have added specific tasks aimed at obtaining technical data needed to enable U.S. manufacturers to proceed, if they choose to do so, with the development of technologically advanced designs.

Question 20: Mr. Beggs, I realize that laser research is not a large portion of NASA's budget, but I do see where you are doing some interesting things with lasers. We are, as a Nation, spending more than $500 million each year on laser and particle beam technology; and my concern is that we are not coordinating this research among the various Federal agencies. Does NASA have any Memorandum of Understanding (MOU), letter of agreements (LOA), or any such arrangement with other agencies with regard to laser technology?

Answer 20: NASA/DOD coordinating functions are conducted by the Space Research and Technology (SRT) Panel of the Aeronautics and Astronautics Coordinating Board (AACB). In 1981, the SRT Panel agreed that the High Energy Laser Review Group (HELRG) would be used for coordination of Federal efforts in high energy laser research and technology. Accordingly, in July 1981, a memorandum was signed between DOD and NASA to coordinate their high energy laser activites through HELRG. This group, which also includes DOE, meets semiannually and coordination occurs through information exchange. NASA also coordinates all low power laser activities in communications technology, sensing and ranging with DOD through laser working group D of the Advisory Group on Electron Devices (AGED).

RESEARCH AND PROGRAM MANAGEMENT

Question 21: Mr. Beggs, in my opening statement I expressed the concern that the NASA organization and structure, which we have carefully developed and is so vital to the United States, may have problems in the near future. Specifically, as many ongoing programs are nearing completion, as space commercialization materializes, as Shuttle operations go to private industry, and as the military assumes more responsibility, does NASA management have a long range plan that will fully utilize the NASA talents and resources to continue to meet the objectives set forth in the Space Act?

Answer 21: The National Space Policy, set forth in National Security Decision Directive No. 42 and announced by the President on July 4, 1982, reaffirms the Nation's commitment to the exploration and use of space in support of national well-being. To carry out its responsibilities in connection with that commitment, NASA maintains a process for conducting its program planning that involves its senior officials and managers, integrates the most advanced thinking available throughout the Agency, and incorporates suggestions and recommendations from many outside persons and organizations such as the NASA Advisory Council and advisory boards sponsored by the National Academies. That planning has identified projects that should be undertaken in all of NASA's traditional areas of science and technology through FY 1988 and, in some cases, to and beyond the end of the century. A report on that planning is in process.

Question 22: Mr. Beggs, the Alabama Space and Rocket Center conducts a program called the United States Space Camp. The Camp will this Summer provide 1,400 boys and girls from 45 states a chance to see today's space program up close and to visit research laboratories that support the space program. Space Camp permits our younger generation to become excited and motivated to take additional science and math courses.

As the total number of 18 year olds in the population continues to decrease into the 1990's, we must ensure that talented students will want to enter science and engineering to meet future needs. At the Space Camp the students spend five days learning about rockets, astronaut training, Space Shuttle, computers, and design theory as well as career opportunities. What role does NASA play in the Space Camp, and what role will it play in the future?

Answer 22: The NASA Marshall Space Flight Center (MSFC) Public Affairs Office assisted in the planning and design of the initial curriculum for Space Camp in 1982. Our operational support to the camp included briefings at the Neutral Buoyancy Simulator, Payload Crew Training Complex, and the Beam Builder. Lectures were provided at the Marshall Center and at the camp on Materials Processing in Space, Technology Transfer, the Shuttle Student Experiment Program, and Large Space Structures. There was also an evening "rap session" on engineering led by a young engineer from MSFC. NASA provided space hardware and lunar samples for demonstrations, and furnished films and educational literature. All support was provided on the basis that it did not interfere with normal MSFC work, and some support was provided after duty hours on a voluntary basis by Center employees. Assistance to the Space Camp in 1983 and in future years is planned to continue as above. We are also assisting the planning and curriculum design for an Advanced Space Camp.

Senator **Trible**. Mr. Beggs, and gentlemen, we thank you for your testimony today, and for your good effort in fashioning the NASA proposals before us.

The chairman and I have many additional questions which we will submit for the record and ask for you to answer in due course, and not prolong your testimony here today.

I thank you very much. The meeting is adjourned.

[Whereupon, at 11:25 a.m., the subcommittee meeting was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1984

TUESDAY, MARCH 15, 1983

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:05 a.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. This is the last of 3 days of hearings on the part of the Subcommittee on Science, Technology, and Space on the NASA authorization for fiscal year 1984.

On the first day, closed hearings were devoted to a review of our national defense activities in aeronautics and space to determine how these are impacted by the proposed NASA program for fiscal year 1984. NASA Administrator James Beggs and his deputy, Dr. Hans Mark presented the proposed fiscal year 1984 programs and budget on the second day of hearings. They reviewed with the subcommittee a number of critical issues including the requirements for a five-orbiter fleet for the space transportation system, planning activities for a permanent manned space facility, better utilization of data in research and analysis activities, and specific programs in aeronautical research and technology.

The last of these issues will be the first addressed at today's hearing. A unique partnership has been established over the last 50 years between the industrial and academic aeronautical communities on the one hand, and NASA and its predecessor, the National Advisory Committee on Aeronautics. This remarkably successful partnership has led to U.S. worldwide preeminence in both the military aircraft and commercial transport markets.

Last November the President's Science Adviser formally acknowledged this partnership and NASA's role in providing basic technology. We welcome and endorse this position. Our interest now is to see that the programs proposed for fiscal year 1984 are consistent with the administration's policy.

Many of our hopes for space depend on the successful commercialization of the unique advantages which this realm provides. More private sector involvement can greatly improve the prospects for successful commercialization. We are now considering what this involvement might be. That is, what responsibilities should or can be assumed by the private sector and which more properly belong with the Government. The successful commercialization of the Space Shuttle offers the pivotal example of this challenge; one which we will address today.

At the moment, the question of the private sector role is focused on the President's recent decision to transfer the Nation's civil operational land and weather remote sensing satellites to the private sector. Whatever the merits of the decision are, they have been obscured by the regrettable lack of consultation by the administration with those of us in the Congress whose help is needed to secure approval of any transfer.

The President's proposal is not a primary subject of today's hearing, but it will be taken up by the committee in separate hearings in the near future.

Capitalizing on the promise of space also depends on how well we succeed in space science and applications. This committee had concerns in the past that the demands of taking the Space Shuttle from a research program to an operational system put serious stress on NASA's space science and applications programs. The proposed fiscal year 1984 NASA program seems to offer a better balance than that which we have taken up in recent years.

We look forward to examining these programs more closely today. We have with a number of distinguished witnesses, and it is my pleasure to welcome them here today. But before we do that, Senator Trible, did you have an opening statement?

Senator TRIBLE. No, Mr. Chairman, no opening statement, but I will ask some questions at the appropriate time. Thank you.

Senator GORTON. We have a very distinguished air transport panel with us here this morning. I will ask that a consensus statement on its part be presented by Mr. Hopps. Any formal written statement of the other members will, of course, be included in the record in full, but after Mr. Hopps' statement, those of us who are here present will ask questions and will ask questions for comments by all of the members of the panel.

Mr. Hopps?

STATEMENTS OF RUSSELL HOPPS, VICE PRESIDENT AND GENERAL MANAGER, LOCKHEED CALIFORNIA CO.; ROBERT C. HAWKINS, GENERAL MANAGER, ADVANCED TECHNOLOGY OPERATIONS, GENERAL ELECTRIC AIRCRAFT ENGINE GROUP; ROGER D. SCHAUFELE, VICE PRESIDENT, ENGINEERING, DOUGLAS AIRCRAFT, McDONNELL DOUGLAS CORP.; M. E. SHANK, DIRECTOR OF ENGINEERING, PRATT & WHITNEY AIRCRAFT GROUP, UNITED TECHNOLOGIES CORP.; H. W. WITHINGTON, VICE PRESIDENT, BOEING COMMERCIAL AIRPLANE CO.; JOHN RALPH, SENIOR VICE PRESIDENT, OPERATIONS AND TECHNICAL SUPPORT, AIR TRANSPORT ASSOCIATION OF AMERICA

Mr. HOPPS. Good morning. Mr. Chairman, members of the subcommittee, ladies and gentlemen, my name is Russell Hopps, I am vice president and general manager of engineering and development for the Lockheed California Co. I have been intimately involved in aeronautical research, technology, and aircraft development for 27 years. I have been asked to be the industry spokesman by those you requested to testify. They have accompanied me and represent the airframe and engine manufacturing industry in both the military and civil aviation field.

They are Mr. Bob Withington, vice president of Boeing Commercial Airplane Co.; Mr. Roger Schaufele, vice president of engineering for Douglas Aircraft, McDonnell Douglas Corp.; Mr. Bob Hawkins, manager of advanced technology, Aircraft Engine Group, General Electric; Dr. Bud Shank, director, engineering-technical for commercial engineering, Pratt-Whitney Group, United Technologies Corp. And also joining us at the table is Mr. John Ralph, senior vice president of the Air Transport Association.

We welcome the opportunity to speak to you on the subject of the adequacy of the 1984 aeronautics budget. I will paraphrase and editorialize a little the testimony which I have submitted to you. When asked to be the spokesman, I believed it would be difficult to combine all the possible diverse views of the members of our industry into a statement that had unanimous support. Each of us has viewed the NASA programs from a different perspective, and yet, the extent of our agreement is substantial. In fact, I can say for what we are presenting, there is but one point that only one of the companies had a differing opinion.

These common agreements regard the general nature of the industry itself, the need for a strong aeronautical research and technology base, the Government's role in technology development and many of the specific NASA programs. I will make the consensus statement which includes the views of my company, the Lockheed Corp. Two of my colleagues, Mr. Schaufele and Dr. Shank, will then make a short statement on their companies' views which were not contained within the consensus statement. Afterwards, we would be pleased to answer any questions you may have.

First, we believe it is important to give a brief description of our industry to illustrate its large overall impact on the U.S. economy. Employment in the aerospace industry, which includes aviation, space, missiles, and some nonaerospace products, totals nearly 1.2 million. About 600,000 jobs can be attributed to the production of aircraft engines and parts. Companies in all 50 States contribute to this Nation's aircraft production. Overall, aircraft sales were approximately $34 billion in 1982. Aerospace exports amounted to $15 billion in 1982. The vast majority of this amount, almost $14½ billion, is due to the aeronautics side of our industry. That is, aircraft engines and parts.

In recent years, aviation products have been the biggest single contributor of any manufacturing industry to this Nation's net balance of trade. The aviation industry has produced military and civil aircraft and equipment that are second to none. Aviation is also a prime ingredient to our Nation's security. The vast majority of aeronautic R&T supports both civil and military applications. Continued progress in aviation is vital to our national security, international policies, and to an efficient and reliable air transportation system. A healthy aviation industry is a major contributor to the economy and welfare of the United States.

Last November, the White House Office of Science and Technology Policy released its reports on national aeronautics. Among its findings it concluded that aeronautics is not a mature industry, that it is not a sunset industry, and that significant advances are possible that have potentially high payoffs. We in the industry never believed that we were in a sunset industry. Further, the report stated that the Government should take a major role in aeronautical R&T.

Integrating advanced technologies, the report stated, could produce more than a 50-percent increase in fuel efficiency for large military and civil transport aircraft, and more than a 30-percent reduction in direct operating costs. Even if only a small part of this were to be realized, the benefits would be enormous.

For example, the U.S. airlines industries' fuel consumption, if it were reduced by 5 percent, would save about $500 million annually. This figure exceeds the annual profit of the U.S. airlines for 12 of the last 15 years.

Although fuel prices have decreased recently, there is a real danger in becoming complacent in assuming that this trend will continue, and that further advances in technologies that save fuel will become less important. Our Nation will continue to be dependent on oil for many years, and much of it will have to be imported from politically unstable areas. We must continue our efforts to reduce fuel consumption in both military and commercial aircraft.

Further, the OSTP report pointed out that military aircraft can incorporate improved survivability features and achieve substantially greater mission effectiveness and provide greater range. Increased payloads, civil and military rotorcraft are possible with 100 percent speed and range increases, and the potential gains that they list goes on and on. And we agree. Never have we in the industry been more confident in the future possibilities in aviation.

Therefore, aeronautics is a fine example of the high technology that the Government seeks to encourage and should encourage. To move a proposed vehicle from concept to fruition is costly and often requires a long period of time. Development of a new commercial engine or airplane costs billions, certainly in combination, billions; often, more than the net worth of a company.

The company, with this large investment, must employ technologies that entail relatively modest risk, even to the extent of foresaking some technologies with potentially greater benefits. Development of technologies of high risk and long development timespans is an area where the Government can and should take the lead if this country is to retain its prominent position, vis-a-vis foreign competition, which does involve various forms of government support.

All companies can benefit from work that NASA and DOD perform. One of the greatest problems in the industry today is the need to slow the tremendous increase in both the development cost and the recurring cost of aircraft. There are many studies today that show that the military cannot afford that which is already on their plate. The costs are escalating too rapidly. Work done by NASA will mitigate this rising cost by assuring technology readiness through proof of concept work.

It is also necessary for us to state that ever since NACA, NASA's predecessor, was founded, there has been an excellent Government laboratory-industry relationship that resulted in aeronautical technology development that has produced outstanding aerospace products and provided many national benefits. We in the industry have a great respect for NASA, it programs, and its personnel. We believe that it is one of the best-run agencies in the Government. NASA requests industry recommendations on R&T development through several advisory committees, and these are largely reflected in the NASA programs we are discussing today.

Now, with respect to our more specific consensus comments. First, we wholeheartedly endorse the OSTP aeronautical research and technology policy. This panel considers it an excellent and comprehensive report, and commends the members of the working group for their recognition of the high value of aeronautical research.

Basically we support the general thrust of programs NASA has proposed. We would prefer to see a higher level aeronautical budget, although we recognize that in government, as in industry, resources are limited.

Our main point is, however, it does not appear that the funding is consistent with the goals of the OSTP aeronautical R&T policy. We as a whole believe the funding should be increased by a minimum of 20 percent, or approximately $60 million. In the current plan—there is almost total abandonment of some systems technology research programs, particularly in the areas of subsonic aircraft and advanced propulsion. We feel that the system's programs are vital to provide the focus and guidance for an aggressive R&T base and should not be sacrificed. In both 1981 and 1982 the Congress did provide needed additional augmentation. We as a group hope you can do this again.

Just a note. It is interesting that just a sliver of the space budget could do wonders for aeronautics research.

We, the industry, are disappointed in the support given to the structures and materials area. Enhanced funding should be considered for primary composite structures; a technology that offers the possibility of reducing both fuel consumption and also, the unit costs.

Laminar flow control is an excellent example of a technology offering great promise, but one which the industry cannot pursue adequately on its own because of the large risk. It is a natural role for NASA to perform research in such a high risk technology, but LFC has, unfortunately, been zeroed in the 1984 budget.

The advanced turboprop or propfan offers good potential in both the military and civil sectors. NASA should continue this work, but we fear that the funding is inadequate to maintain the pace required to capture many of its potential markets. It has application in military derivative aircraft, as well as good potential in the short-range commercial marketplace and most of our commercial aircraft fuel is consumed at the very short ranges.

Funding for advanced turbofan propulsion system technology work should be enhanced. The powerplant is the key to new aircraft development. Without it, it is highly unlikely that any company will commit to new civil aircraft or the military to new tactical aircraft. Many of the improvements in today's aircraft have been the result of advancements in the powerplant technology.

Further, all but one of the members of our panel believe that if NASA is unable to obtain additional funds, some change in the distribution of funds may have to occur. For example, they believe that the numercial aerodynamic simulation research is very important, and will eventually provide needed understanding of complex flow fields, but suggest that the 1984 expenditure may be slightly too aggressive if additional funding cannot be obtained. We all hope, of course, that the additional funds can be provided without this reduction.

These, then, were the areas of agreement, and it is obvious that we, the industry, have very common concerns and views.

In summary, never before in our industry have we been more confident that our Nation's future in aeronautics has the possibility of moving ahead at an even more rapid pace. But the industry cannot do it alone. Government and industry must each play a role in this necessary partnership. Aeronautics must not become another industry that suffers decay because of foreign competition. We cannot change the rest of the world; we must accept the fact that in virtually all other industrial nations, a marriage has taken place between government and the aerospace industry. We must take stronger measures to enhance the aeronautical research base of our Nation.

We in the industry note that the OSTP report made a clear call for increased aeronautical R&T, but this country's investment in aeronautical R&D as a percent of sales has been dropping steadily over the past decade. In the meantime, foreign aeronautical development, both friendly and hostile, has been steadily increasing. Foreign commercial wide body transports are accounting for a substantial portion of the market. Soviet military aircraft development has continued unabated.

If we are to avoid losing transport manufacturing jobs to the Europeans and the Japanese and maintain the other national benefits that result from a leadership role in aeronautics, we must increase our support of aeronautical research and technology. Fortunately, there is much synergism between civil and military aeronautical R&D. Both sectors will benefit from expanded research.

As we have stated and as the OSTP study affirms, industry cannot on its own provide this leadership role. It needs Government support, particularly for the long-term, high risk technology programs. We believe that the industry and NASA working together, with increased congressional support, can maintain our preeminence in aeronautics.

Thank you very much for giving us the opportunity to express our thoughts and concerns. And now I will ask Mr. Roger Schaufele to make his statement, which will be followed by that of Dr. Shank. Thank you.

Mr. SCHAUFELE. Mr. Chairman, and members of the subcommittee, my name is Roger Schaufele, I am vice president of engineering of Douglas Aircraft Co., a component of McDonnell Douglas Corp. It is an honor and a privilege to be able to present to you today our comments on the NASA aeronautics program as proposed for fiscal year 1984.

We are heartened by the fact that the executive branch of the U.S. Government is willing to increase the NASA aeronautics budget for fiscal year 1984 to some $300 million, up 7 percent from fiscal year 1983, and to do this in this year of severe budget pressures.

Competition for the free world civil air transport business is becoming fierce, as foreign governments recognize the benefits to their society from the high technology air transport industries, and establish goals and provide the resources to secure increased shares for themselves. U.S. industry is being hard pressed to maintain its historical dominance of these markets. NASA has a unique role to play in this international competition, and it is our desire to assist them in every way possible to realize the maximum benefit for the United States, and that is what we would like to address for you here today.

This concern, as well as a number of related issues, were evaluated by a multiagency governmental study group under the chairmanship of the Office of Science and Technology Policy in the Executive Office of the President, an we want to publicly support their recommendations.

They confirmed the importance of aeronautics to national defense and to the national transportation system, and recommended a continuation of the Government's role in aeronautical research and technology to insure the timely provision of a proven technology base to support future development of superior U.S. aircraft and a safe, efficient and environmentally compatible air transportation system.

The study group noted that the aircraft industry is a major U.S. enterprise. It noted that a major factor influencing the future prospects for U.S. manufacturers is the sustained development and availabilty of new and advanced technology. Our technology assessments at McDonnell Douglas convince us that there are large potential payoffs still available from aeronautical research and technology efforts, spanning the full range of NASA activities from fundamental knowledge gained through basic research to the proof of concept or technology validation stage, so critical before applications can be considered for future military or civil aircraft applications.

We believe NASA has a unique capability and a unique responsibility in the area of technology validation, and it is in this area that we believe the fiscal year 1984 NASA program should be strengthened. We do not want to address the R&T base here today, but we do want to say that we believe NASA needs to reestablish systems programs as it is in this area where NASA may make its greatest contribution through the mechanism of multiple technology programs, cooperatively and continuously pursued.

Several key system areas have been identified as having high potential payoff in the downstream years, which represent programs that are too high right, too long in return of capital or are too expensive for industry to do alone. This is where NASA's systems activities are needed to keep this country competitive. Previous NASA efforts have done much in developing the base research and technology in many areas, and work has progressed to the point where industry, in cooperation with NASA, has begun to invest its limited research funds in support of several of these proof-of-concept systems programs.

Some of the NASA systems programs have been outstanding successes in the past and have given the latest U.S. civil transports dramatic improvements in fuel efficiency. Many of these programs show promise of even further improvements and need to be continued. Specifically, the systems programs we endorse and which should be included in the NASA aeronautics program for fiscal year 1984 are:

The subsonic aircraft systems which includes composite wing primary structures, deserves our highest priority; laminar flow control, which should be funded to continue the successes demonstrated to date; active controls, and supercritical wing and configuration integration aerodynamics should also be funded.

Advanced propulsion systems which includes the advanced turboprop program should be funded in fiscal year 1984 to insure realization of an early flight research program, as well as continuation of the successful energy efficient engine and advanced turbofan effort.

Reinstitution of an advanced metals and structures systems program which offers a broad range of potential benefits. This program should include metal matrices, advanced lithium aluminums and advanced metals that are just now emerging from the laboratories.

As noted previously, the foreign government-industry technical community has established R&D programs in many of these key areas in an attempt to get ahead of the U.S. industry on future product offerings. We must maintain a momentum in aeronautics, and we look to NASA to help guide us.

These are the principal areas that we wanted to address today. I want to thank the committee for giving us the honor and privilege of being able to focus on these systems studies activities here for you this morning. Thank you.

Dr. SHANK. Mr. Chairman, I am Bud Shank, director, Engineering-Technical, Commercial Engineering, Pratt & Whitney Group of United Technologies Corp. I want to thank the committee on behalf of United Technologies for this opportunity to share with you our views on the administration's budget request for NASA's aeronautics program. I have a very brief statement that will address particular aspects of the propulsion arena of the aeronautics budget.

My distinguished colleague, Mr. Hopps, has said that the powerplant is the key to new aircraft development. I would point out that powerplant development leads the airframe by 1 to 2 years, depending on circumstances. Yet, if one looks at the NASA budget under the heading "Systems Technology Programs," the item "Advanced Propulsion Systems Technology" proposed for fiscal year 1984 is zero. This is distinctly different from prior years.

I should like to discuss in a little more detail some of the possible consequences of this. For example, foreign manufacturers are already pursuing turboprop aircraft. The French are already in the fourth year of their own advanced propfan program with a test of a propfan model planned for 1984 and 1985. The Russians have predicted and are predicting that propfan Soviet aircraft will enter service in the 1990s, at the same time or even before the West manages to put a propfan into service.

The timing of the advanced turboprop program is critical. Industry must be ready for the market opportunity expected to occur in the early 1990's when current aging short- to medium-term aircraft will need replacement. Studies have shown that there is a potential swing of $50 billion in trade balance hinging on capturing this market.

Also of prime importance is the continuing long-term generic research and technology base effort to advance the state of the art on a broad front in an evolutionary way.

In addition, of course, novel concepts of great promise must be investigated and pursued, where appropriate, to establish proof of concept. In the propulsion area, the advanced turboprop or propfan is a noteworthy example of this.

The fiscal year 1983 NASA authorization bill specifically recommended augmenting the advanced turboprop program with a flight test-bed research program. As yet there has been no action to implement these recommendations, and the program has been omitted from the fiscal year 1984 new initiatives.

Further, there are no new programs to develop technology to carry large turbofan engines beyond the energy-efficient engine, or so-called E-cubed program. Such long-term technology effort is essential to insure continued U.S. leadership in propulsion for future generations of both turbofan and turboprop engines into the next century.

Nearly three-quarters of all current aerospace exports are civil and military transport aircraft. Of the 18.5 billion gallons of fuel consumed in 1980 by U.S. aviation, about two-thirds was consumed by aircraft with large engines, which we define as those over 10,000 pounds thrust in a turbofan or 7,500 shaft horsepower in a turboprop.

It should also be noted that by far the major portion of the improvements in jet transport aircraft fuel consumption have come from advances in propulsion systems technology. The greatest potential for fuel savings and trade balance improvement derives from aircraft dependent on large engines and their technology. Yet as I have noted, for fiscal year 1984, unlike previous years, the line item for advanced propulsion systems technology has been deleted.

NASA's energy efficiency engine program has provided substantiation of many new propulsion technologies. Many of these have been applied to Pratt & Whitney's PW2037 engine with 37,000 pounds of thrust, now under development at a cost to us exceeding a billion dollars. This is our money and our risk.

When this engine enters service on the Boeing 757 in 1984, it will be the most fuel-efficient engine of its type in the world. A major portion of the fuel consumption improvement can be attributed directly to the technology arising in the proof-of-concept E-cubed program.

To illustrate the competitive importance of that improvement, it means that the engine is approximately 5 to 8 percent lower in fuel consumption than its only competitor for the 757, an engine manufactured in Great Britain. In addition, the E-cubed technology is also being applied to the new PW4000 family of engines with a thrust range of 48,000 to 60,000 pounds, to be certificated in 1986.

We therefore recommend that NASA should adhere to its July 1981 submittal to the Congress of the $198 million overall accelerated and enhanced program to establish technology readiness for the advanced turboprop by 1988, so that industry with its own funds will be able to develop propfan aircraft by the 1990's. This engine will have a better fuel consumption by 15 to 20 percent when compared to alternative contemporary turbofan aircraft engines available at that time. Specifically, in fiscal year 1984, as much as $20 million should be applied to this purpose.

Our second recommendation is that the advanced turbofan research program, so-called ATR, which is a follow-on to E-cubed, should be funded in fiscal year 1984 to the amount of $4 million. This program will provide engine technology applicable to the second generation of the advanced turboprop engine as well as advanced turbofans for the post year 2000 era.

That completes my statement, Mr. Chairman. I thank you for the opportunity to appear.

Senator GORTON. Thank you, Dr. Shank.

Mr. Hawkins, I think we will direct the first question to you, though if others wish to comment on it, they may. In its fiscal year 1984 budget systems technology program, NASA asked for funding for advanced turboprop, laminar flow control and advanced transport operating systems moneys. But the request was denied. I wonder if you could comment on the benefits to the industry of these technologies and whether or not you believe that in any or all of them private industry can or will take over that responsibility if NASA is unable to do so.

Mr. HAWKINS. Mr. Chairman, I think essentially all of those technologies have been mentioned in the testimony this morning as being important and very significant to the industry and as has been mentioned, as being high-risk long-term technologies, such as the laminar flow. I think many of us looking at the high-risk long term, wonder if the industry will be able to take on some of these technologies without up-front technology programs that we would like to see NASA do.

Senator GORTON. How important are they for the future?

Mr. HAWKINS. I think they are quite important. If we talk about gains in fuel consumption like 20 percent, which as we can see is a very, very large gain, if our European competitors develop this technology—I think the inroads in this country of the sales of commercial airplanes could be very significant. It would be a competitive situation that we in this country in our industry would certainly not like to see happen.

Senator GORTON. What is the minimum level of funding from the point of view of NASA necessary to keep these projects on track?

Mr. HAWKINS. Mr. Chairman, Mr. Hopps mentioned a figure of 20-percent increase for 1984.

Senator GORTON. Yes; I know he did. But my question was the minimum level.

Mr. HAWKINS. As an industry, I think that is pretty much a minimum we need. We state that number, Mr. Chairman, because we think that we would like to see a number significantly larger than this. But from where we sit today and the timing that is involved in getting NASA programs on line for 1984, we think that is an appropriate amount, considering the time. And we would like to see, and we think the technology opportunities justify, a very considerably larger investment than the $60 million that we mentioned.

Senator GORTON. I think it was Mr. Schaufele who made certain remarks about the new start, the numerical aerodynamic simulator; was it not? Or was it Mr. Hopps?

Mr. SCHAUFELE. It was Mr. Hopps in his statement.

Senator GORTON. OK. Then, Mr. Hopps, this question will be for you. First I would like to know what the benefits for the industry are from the NAS program, and I believe that your testimony indicated that we might be starting on it too fast. And I would like you to amplify on that and on where you would prefer to see a redistribution of moneys in this area if we were disposed to do so.

Mr. HOPPS. This was part of our consensus statement, where four of the five members just felt that, as we stated in the statement, maybe more money will not be available. We really think it is a very necessary program and should be continued, but if a trade had to be made four of the five members felt that this might be a place to alter—maybe just slow slightly. We are not saying that that work is not very important. It will have large benefits, but they are farther downstream before they fully become effective, and useful. And we want the program. It is important.

Senator GORTON. How much of a transfer could be safely made?

Mr. HOPPS. We had among the opinions from one party that the reduction should be zero. In the others, they ranged from $4 million on our part, to another company that went as far as $10 million. The other two were in that range.

Senator GORTON. A fairly broad range of opinion in your group on that.

Mr. HOPPS. But four of the five saying that if something had to be done, maybe that was the place to just slow slightly. We would prefer not to. It is very important work that you are talking about. But again, it is the near term, the next 5 to 7 years, that some of these markets will escape from us if we do not do some of the systems technology work.

Senator GORTON. Would you comment—and if someone else wishes to interject a comment, he may do so—on the transfer of aeronautical research results between NASA and DOD and then between the two of them and your own industry? Is this done efficiently and constructively, or are there losses in both time and quality in the process?

Dr. SHANK. Well, your first question was transfer from NASA to DOD.

Senator GORTON. Between the two.

Dr. SHANK. And I am not sure that I can comment on that meaningfully in the broad sense concerning NASA and DOD as two Government agencies or departments. I will say that the commercial engineering division at Pratt & Whitney and the Government products division are very closely tied together. Any technology that we acquire anywhere moves into that arena very quickly.

Also, I think in the propulsion arena that we make very rapid use of NASA technology. The E-cubed program was started in March 1978. We started hard design of the PW-2037 on January 1, 1980 and it will be certificated in December of this year. Thus it is obvious that even as technology was being developed in E-cubed it was being utilized in the PW-2037. This is very rapid and efficient transfer.

Senator GORTON. Yes, Mr. Withington.

Mr. WITHINGTON. I agree that the transfer of NASA generated technology within the companies is very good. I also believe that the transfer between DOD and NASA has historically been pretty good. I am involved in the NASA Advisory Council, and one of the missions that we have is to review that situation to see whether there are not some areas that can be improved. So we are actively working on that in the NASA Advisory Council.

But it has historically been pretty good. The military has had members on the advisory groups in the past, and it is not too bad.

If I might, Mr. Chairman, inasmuch as I am the one out of five that did not agree with the consensus, I think it is appropriate that I state my position relative to the choice of the sacrificial lamb to make our systems budget proper.

Senator GORTON. Please do.

Mr. WITHINGTON. I would like to say in the first place I agree completely with my colleagues that the problem with the budget as it now stands is that they have taken too much out of the systems area. When we all reviewed the budget last fall, it was, in our opinion, a balanced effort, a balanced program, and it came to about $360 million. And that is the 20 percent that has been discussed this morning.

It was a pretty good balanced program. Each of us did not necessarily agree 100 percent with everything, but through our advisory committees, we said it was a good program. The way it sits now, $60 million was taken out of the systems area and the aeronautics program is now out of balance. I object to using the NAS as a source of funds. In the first place, it is not enough to do any good. And second, it is a very important program itself.

I can give you just one example of the importance of that technique, its computational aerodynamics. Through the use of computational aerodynamics, we were able to locate the nacelle on the 737-300 in a position which our past wind tunnel work would have said would not work. But we worked the problem in the computer. It gave us some leads. We tested it in the wind tunnel, and it worked. So it made a significant improvement.

Today we only have the capability of doing parts of the airplane by this technique. We can do a wing, we can do a wing and a nacelle, we can do a wing and a body intersection. But we cannot do the whole airplane. And the purpose of this program, the NAS program, is to get on with more powerful computers to do a better job. And one of these days we will be able to do the whole airplane.

In our two recent airplanes the flight test results came out 3 or 4 percent better than our predictions, I think primarily because of the tailoring that we did in certain parts of the airplane which was done by this computational aerodynamics.

So to me the NAS is very, very important. My suggestion for how to fix the deficiency in the systems budget has already been mentioned. The first thing we would like to do is see the money put back in, but we recognize that this may not be completely possible.

So my recommendation would be, or the hope would be, that Congress might find it desirable to put some more money in as an investment in aeronautics and whatever that total would be, then I would be very confident that NASA management in the form of Dr. Kerrebrock is perfectly capable of readjusting whatever that total would be to have a balanced program. I think that is the way to do it rather than picking on one element and taking it out.

Senator GORTON. Thank you, Mr. Withington.

Mr. Ralph, OSTP in a report on aeronautical research and technology last November recommended that NASA fund, direct, and implement aeronautical research and technology development programs and support military aeronautical research and technology demonstration programs.

In your view, does the fiscal year 1984 budget request fulfill this recommendation or live up to it?

Mr. RALPH. I think the budget is a little bit austere to accomplish the stated objectives. The kinds of things that the airline industry would be concerned about are continuing advances in propulsion efficiencies that have been referred to, including the propfan and other advanced engine technologies.

We are very much concerned about the structures problem. We would like to see continuing advances in both nonmetallic and metallic structures with the objective of getting the structures fraction of the total weight of the aircraft down. And then related to a broad range of technologies, we would like to see improvements, significant improvements, in reliability or what might be called the durability of systems.

So this budget will not accomplish all of the objectives that we would like to see in the aeronautical research program. We would certainly endorse the 20-percent increment. We are not prepared to argue as to whether or not there should be a sacrificial lamb or whether or not there are other allocations to be made within the budget. Clearly, the first preference is to have a delta added to the budget.

Senator GORTON. Thank you.

Senator Trible.

Senator TRIBLE. Thank you, Mr. Chairman.

Gentlemen, you have advanced unanimous support this morning for the laminar flow control, advanced transport operating system, and the advanced turboprop research and have advocated additional funding for these programs. What is private industry doing in these areas?

Mr. WITHINGTON. I can speak for my company. We in our own research funds try to work on all of these items. They are important. We do not have too much money right now, we are all in a pretty austere situation. Our customers, the airlines, are kind of broke, and we are suffering from that situation.

I have a pretty good research budget, though, and we are working all of these elements, but at a very low level. It is very important to us that we get as much help as we can. I will let the other companies speak for themselves, but we have always tried to do what we can. Our competition from overseas is getting rougher and rougher. The only way we can stay competitive is to be better than they are technically. And we try to put as much money as we can into research.

We appreciate very much what has been done by NASA. In the mid-1970's the ACEE program was a real shot in the arm for the industry. It came at a very appropriate time. Our industry seems to be in about a 10-year cycle, and we were in kind of a low point in the early 1970's when the fuel crisis came along. NASA stepped up to the ACEE program and did such work as starting the composites program. They did a lot of work in some of the system in the cockpit.

All of these have been taken advantage of as seed money and we have gone on from there and incorporated the new technology in our production airplanes. Basically, we all try to work on these things, but it is not enough to do the job as fast as we should to stay ahead.

Mr. **Schaufele**. I would like to reinforce those comments from our standpoint at Douglas Aircraft Co. We are also working in conjunction with the NASA programs in all of the areas that you mentioned above.

However, our priorities are pretty much near term and our resources are limited. The specific advantage of the NASA systems technology programs are that they provide a larger budget source and provide results which are shared with all of industry, and they get you to the point where you can do the necessary large-scale technology validation efforts that are not possible by industry efforts alone.

When we look at the potential benefits for the particular technology areas that you mentioned, but at the same time assess the overall risks associated with them, those are the kinds of programs where the NASA-industry cooperation with the kind of budget levels that are being talked about are really required.

So we continue to work with the problems, but we just are concerned that with the levels that are being identified, both from NASA and from industry, that we are in very grave danger of losing our technological leadership in these potentially high payoff areas. So it is a situation that we think is serious, and that is the primary reason why we have endorsed significantly greater effort on NASA's part in these areas.

Mr. **Shank**. If I may address that same question relative to the propulsion business, Pratt & Whitney also invests a substantial amount of money propulsion technologies. However, as has been indicated, our customers, the airlines are under heavy financial pressures, and this has a very adverse affect on our business.

In view of our industry's near-term funding requirements in order to meet foreign competitive threats, it is unlikely that U.S. industry could commit funding for the high-risk, proof-of-concept work in a timely manner. And, of course, I do point out that once such proof-of-concept work is completed, private U.S. industry, in order to utilize this technology, at its own risk invests 10 times as much to design and develop a product and market it worldwide against foreign competition.

Mr. **Hopps**. I would like to add from the Lockheed Corp., all of the technologies that you mentioned, even with the same financial problems that Bob Withington mentioned—we just lost $2½ billion in a commercial transport which I think is accepted as one of the most efficient transports and a technological leader. Still, we put tens of millions today into the technologies we are talking about, but such money is still not adequate to move ahead with a new airplane program.

In composites, propulsion systems, the propfan, we look at all these programs and technologies. A good example of what NASA has done with their funding is in the active controls program. As you know, the L1011-500 was the first jet transport to be able to expand its span without a structural weight increase. It almost sounds like it is beating the law of physics. It is possible due to the active control systems. We were funded by NASA in that program, and at a stage—I forget the exact number—where we probably had about $7 million of funding, we committed to a more fuel-efficient transport and put something on the order of $40 million into active controls on our own to increase the technology in our L1011-500 transport.

So it is a good example of NASA providing some of the seed money so that industry is able to move faster in certain technologies. And we in the industry just cannot do it alone in these technologies. But I am sure all the companies spend money, in the tens of millions, on these subjects that we are talking about today. But, we need help.

Senator TRIBLE. How does NASA go about transferring the results of its research to the industry? How is that done?

Mr. HOPPS. Broadly, through their documentation, through our advisory committees, through continual visits to the NASA facilities and their visits to our facilities. It is rather extensive.

Senator TRIBLE. Is this information, then, available to foreign nations and foreign competitors?

Mr. HOPPS. Yes, that has been discussed quite often in our advisory committees, and no one has been able to really figure out how to put a halt to it, or at least provide a slowdown. I think we have recommended that it not be completely halted, but that somehow, the U.S. industry be able to take advantage of it first. And so far as I know, we have not really found an acceptable solution to that problem.

Mr. SCHAUFELE. In addition to the avenues that Mr. Hopps has mentioned, there have been a number of NASA-sponsored industry meetings. All of those activities in the advanced technology area, especially in the systems technology, are protected by a mechanism called the FED laws for early domestic dissemination, which gives a lead or an advantage to U.S. industry in making use of the results of those specific system technology efforts.

Senator TRIBLE. How does that work?

Mr. SCHAUFELE. Well, you get kind of a mixed reaction, I guess. We are not in a total position to observe, but I think more of our technology efforts show up overseas than we would like to see. And I think one of the issues addressed in the OSTP policy was trying to develop a better means of protecting the results of research done in the United States for U.S. purposes.

Senator TRIBLE. In the day of increasing competition, is that a problem or a potential problem that should be addressed by the Congress or by the agency?

Dr. **Shank**. I would like to go back to your earlier question first, and then talk about the transfer of information abroad.

Another technique by which NASA-Lewis Research Center, which has propulsion responsibility, disseminates its results to U.S. companies is through workshops, as well as documentation. The problem of NASA documentation going abroad is troublesome. Our United Technologies Hamilton Standard Division, which is where the advanced turboprop work is being done, has definitely established through personal contact that the NASA reports are responsible for the headway in this field made by the French at Aerospatiale. Their technology comes right out of the NASA reports.

I have personally verified that, in past years much of the technology of the fan section utilized by Rolls Royce in its high bypass engine came directly from NASA documentation available through our National Technical Information Service.

We have had many discussions on the problem of technology transfer abroad, both in the NASA advisory committees and with NASA officials.

We must keep in mind that there is no simplistic solution. In the field of aeronautics, if the very fine interaction between the U.S. academic world, industry and the Government is to continue functioning, there are many people within the United States in the universities and industry who must have to have access to NASA reports. One cannot just classify them, for example. I think that would probably do greater harm than leaving it the way it is, although I am very troubled by the way the present system works.

I think some careful examination and discussion will have to be brought to bear before a solution is developed for this problem.

Senator **Trible**. Thank you, Mr. Chairman, I have no further questions. I thank the gentleman.

Senator **Gorton**. I would like to thank the panel. We do have a few additional questions which we will submit through Mr. Hopps in writing, and would appreciate your comment on.

[The information referred to follows:]

Senator **Gorton**. We very much appreciate your being here.

Mr. **Hopps**. Thank you from the whole panel.

[The statements follow:]

STATEMENT OF RUSSELL H. HOPPS, VICE PRESIDENT AND GENERAL MANAGER, ENGINEERING AND DEVELOPMENT, LOCKHEED-CALIFORNIA CO.

Mr. Chairman, members of the subcommittee, ladies and gentlemen, my name is Russell Hopps. I am Vice President and General Manager of Engineering and Development for the Lockheed-California Company. I have been intimately involved in aeronautical research, technology and aircraft development for 27 years. I have been asked to be the industry spokesman by those you requested to testify. They have also accompanied me and represent the airframe and engine manufacturing industry in both the military and civil aviation field. They are: Mr. H. W. (Bob) Withington, Vice President, Boeing Commercial Airplane Co.; Mr. Roger Schaufele, Vice President, Engineering, Douglas Aircraft, McDonnell Douglas Corp.; Mr. Robert Hawkins, Manager, Advanced Technology Operation, Aircraft Engine Group, General Electric Co.; and Dr. M. E. (Bud) Shank, Director, Engineering-Technical, Commercial Engineering, Pratt & Whitney Group, United Technologies Corp.

We welcome the opportunity to speak to you on the subject of the adequacy of the NASA fiscal year 1984 aeronautics budget.

When asked to be the spokesman, I believed it might be difficult to combine all the possible diverse views of members of our industry into a statement that had unanimous support. Each of us views the NASA programs from a different perspective and, yet, the extent of our agreement is substantial. These common agreements regard the general nature of the industry itself, the need for a strong aeronautical research and technology (R&T) base, the government's role in technology development and many of the specific NASA programs. I will make the consensus statement which includes the views of my company. Each of my colleagues will then make a short statement on any of their company's views which were not contained within the consensus statement. Afterwards, we would be pleased to answer any questions you may have.

First, we believe it is necessary to give a brief description of our industry to illustrate its large overall impact on the U.S. economy. Employment in the aerospace industry, which includes aviation, space, missiles and some non-aero space products, totals nearly 1.2 million, a sum exceeded only by the auto manufacturing industry. About 600,000 jobs can be attributed to development and production of aircraft, engines and parts. Some 10,000 companies in all 50 states contribute to this nation's aircraft production. Overall sales in the aircraft sector in 1982 were approximately $34 billion. Aerospace exports amounted to $15.2 billion for 1982. The vast majority of this amount, $14.4 billion, is due to the aeronautics side of our industry, i.e., aircraft, engines and parts. In recent years aviation products have been the biggest single contributor of any manufacturing industry to this nation's net balance of trade. The aviation industry has, we are proud to say, produced military and civil aircraft and equipment that are second to none. Aviation is also a prime ingredient to our nation's security; indeed, about one third of the defense budget is now spent on aeronautical products and their support. The vast majority of aeronautical R&T supports both civil and military applications. Continued progress in aviation is vital to our national security, international policies, and to an efficient and reliable air transportation system. A healthy aviation industry is a major contributor to the economy and welfare of the United States.

Last November, the White House Office of Science and Technology Policy (OSTP) released its report on national aeronautics. Among its findings it concluded, contrary to a sometimes expressed view, that aeronautics is not a mature industry—it is not a sunset industry—and that significant future advances are possible that have potentially high payoffs. We in the industry never believed that we were a sunset industry. Further, the report stated that the government should take a major role in aeronautical R&T.

Integrating advanced aeronautical technologies, the report stated, could provide more than a 50 percent increase in fuel efficiency for large military and civil transport aircraft and more than a 30 percent reduction in direct operating costs. Even if only a part of this were to be realized, the benefits would be enormous. If, for example, the U.S. airline industry's fuel consumption were reduced by only 5 percent it would save about $500 million annually. This figure exceeds the annual profit of the U.S. airlines in 12 of the past 15 years.

Although fuel prices have decreased recently there is a real danger in becoming complacent in assuming that this trend will continue—and that further advances in technologies that save fuel will become less important. Our nation will continue to be dependent on oil for many years and much of it will have to be imported from politically unstable areas. We must continue our efforts to reduce fuel consumption in both military and commercial aircraft.

Further, the OSTP report pointed out that military aircraft can incorporate improved survivability features and achieve substantially greater mission effectiveness. In addition, civil and military rotorcraft are possible with 100 percent speed and range increases. The list of potential gains goes on and on. Never have we in the industry been more confident in future possibilities.

Therefore, aeronautics is a fine example of the high technology that the government seeks to encourage—and should encourage. To move a proposed vehicle from concept to fruition is costly and often requires a long period of time. Development of a new commercial engine or airplane costs billions, often more than the net worth of a company. The company, with this large an investment, must employ technologies that entail relatively modest risk, even to the extent of forsaking some technologies with potentially greater benefits. Development of technologies of high risk and long development time spans is an area where the government can and should take the lead if this country is to retain its prominent position vis a vis foreign competition involving various forms of government support. All companies can benefit from work that NASA and DoD perform. One of the greatest problems in the industry today is the need to slow the tremendous increase in both the development cost and the recurring cost of aircraft and engines. Work done by NASA will mitigate this rise in costs by assuring technology readiness through proof of concept work.

It is also necessary for us to state that ever since NACA, NASA's predecessor, was founded in 1915 there has been an excellent government laboratory/industry relationship that resulted in aeronautical technology development that has produced outstanding aerospace products and provided many national benefits. We in the industry have a great respect for NASA, its programs and its personnel. We believe that it is one of the best run agencies in the government. NASA requests industry recommendations on R&T development through several advisory committees and these are largely reflected in the NASA programs we are discussing today.

Now, with respect to our specific comments:

First, we wholeheartedly endorse the OSTP Aeronautical Research and Technology Policy. This panel considers it an excellent and comprehensive report and commend the members of the working group for their recognition of the high value of aeronautical research.

Basically, we support the general thrust of programs NASA has proposed. We would prefer to see a higher level aeronautical budget, although we recognize that in government, as in industry, resources are limited. However, it does not appear that funding is consistent with the goals of the OSTP aeronautical R&T policy. There is almost total abandonment of some Systems Technology Research Programs particularly in the areas of subsonic aircraft and advanced propulsion. We feel that the systems programs are vital to provide the focus and guidance for an aggressive R&T base and should not be sacrificed. In both 1981 and 1982 the Congress did provide needed additional augmentation. (It is interesting to note that just a sliver of the space budget could do wonders for aeronautics research!)

We, the industry, are disappointed in the support given to the Structures and Materials area. Enhanced funding should be considered for primary composite structures—a technology that offers the possibility of reducing both fuel consumption and unit costs.

Laminar flow control is an excellent example of a technology offering great promise but one which the industry cannot pursue adequately on its own because of the large risk. It is a natural role for NASA to perform research in such a high risk technology but this has, unfortunately, been zeroed in the 1984 budget.

The advanced turboprop or propfan offers good potential in both the military and civil sectors. NASA should continue its work out but it appears that funding is inadequate to maintain the pace required to capture many of its potential markets. It is believed by the airframe manufacturers that the speed for the aircraft could, however, be reduced to Mach=.70. Such a speed is sufficient for military aircraft that would probably employ this powerplant and it would also satisfy the needs of short-haul commercial transports. Most of our commercial aircraft fuel is consumed at the very short ranges and a higher speed is not required or desired.

Advanced turbofan propulsion system technology work must be enhanced. The powerplant is the key to new aircraft development. Without it, it is highly unlikely that any company will commit to new civil aircraft or the military to new tactical aircraft. Many of the improvements in today's aircraft have been the result of advancements in the powerplant technology.

Further, some members of our panel believe that if NASA is unable to obtain additional funds, some change in the distribution of funds could occur. They believe that the Numerical Aerodynamic Simulation research is very important and will eventually provide needed understanding of complex flow fields but also believe that the 1984 expenditure may be slightly too aggressive. A more conservative level may be prudent and might allow some support to the previously mentioned underfunded programs. We all hope, of course, that the additional funds can be provided without this reduction.

These, then, were the areas of agreement and it is obvious that we, the industry, have very common concerns and views.

In summary, never before in our industry have we been more confident that our nation's future in aeronautics has the possibility of moving ahead at an even more rapid pace. But, the industry cannot do it alone. Government and industry must each play a role in this necessary partnership. Aeronautics must not become another industry that suffers decay because of foreign competition. We cannot change the rest of the world—we must accept the fact that in virtually all other industrial nations a marriage has taken place between government and aerospace industry. We must take stronger measures to enhance the aeronautical research base of our nation.

We in the industry note that the OSTP report made a clear call for increased aeronautical R&T. But, this country's investment in aeronautical R&D as a percent of sales has been dropping steadily over the past decade. In the meantime, foreign aeronautical development, both friendly and hostile, has been steadily increasing.

Foreign commercial transports, which before the late 1970's were a negligible factor in total world sales, accounted for about 40 percent of widebody aircraft sales (essentially the only market in which they compete) in the 1979 to 1982 time period. Soviet military aircraft development has continued unabated. If we are to avoid losing transport manufacturing jobs to the Europeans and the Japanese and maintain the other national benefits that result from a leadership role in aeronautics, we must increase our support of aeronautical research and technology. Fortunately, there is much synergism between civil and military aeronautical R&D; both sectors will benefit from expanded research. As we have stated, and as the OSTP study affirms, industry cannot on its own provide this leadership role. It needs government support, particularly for long term, high risk technology programs. We believe that industry and NASA working together, with increased Congressional support, can maintain our preeminence in aeronautics.

Thank you very much for giving us the opportunity to express our thoughts and concerns.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

Question. The fiscal year 1984 budget request contains funding in the Research and Technology Base for the Integrated Program for Aerospace-vehicle Design (IPAD) data management program. Does private industry, in fact, have its own data management programs that provide the same capabilities as the IPAD program?

What work is private industry now doing in this area of data management?

Answer. IPAD is adressing the major problem of defining and implementing a data base management system for a large scale distributed computer system networked to mainframe computers having very large resident data bases.

Private industry does not have management systems that can satisfactorily handle this problem. In fact, the industry is now taking first steps to implement a Relational Data Base approach that was developed by the IPAD program (RIM).

Private industry has been strongly supportive of the IPAD program, as evidenced by the very active participation of a large number of companies as members of the Industry Technical Advisory Board (ITAB) to IPAD. The industry considers that IPAD has provided, and should continue to provide, a strong and necessary stimulus to the development of management systems for computer-aided design and manufacturing.

QUESTIONS OF SENATOR HEFLIN AND THE ANSWERS THERETO

Question. Is your company's computational capability currently a limiting factor in your ability to perform advanced aircraft design work such as Lockheed has often excelled in?

Answer. No, it is not. As you probably know Lockheed is an industry leader in computerized design and manufacture; our licensed system is now in use by many major corporations.

Question. In what time frame would you place the contribution of NASA's proposed numerical aerodynamic simulator to the enhancement of your company's or industry's design capability and efficiency.

Answer. The contribution of this NASA program will not occur at any particular date but rather will provide an evolutionary enhancement. Its use will expand extensively in the future years as the system itself develops. It will allow aerodynamic experimentation to become much more efficient since such efforts would be supported by very sophisticated and almost "visual" analysis techniques.

Question. Was your industry panel able to suggest why the Agency or the Administration has cut off the prop fan development program in fiscal year 1984 without any funding for the flight research phase which seems so clearly encompassed by its own policy statements?

Answer. Our panel simply believed that there were total budget limitations and that the systems programs were reduced because it must have been assumed that these programs were those that could most likely be funded by industry. Further, with limited funds NASA should probably concentrate on the more fundamental research that provides the path to the future.

STATEMENT OF ROGER D. SCHAUFELE, VICE PRESIDENT, ENGINEERING, DOUGLAS AIRCRAFT CO., MCDONNELL DOUGLAS CORP.

Mr. Chairman and members of the subcommittee, it is an honor and privilege to be able to present to you today comments on the NASA Aeronautics Program as proposed for fiscal year 1984.

We are heartened by the fact that the Executive branch of the U.S. Government is willing to increase the NASA aeronautics budget for Fiscal Year 1984 to some $300 millions, up 7 percent from Fiscal Year 1983 and do this in this year of budget pressures. Competition for the free world civil air transport business is becoming fierce, as foreign governments recognize the benefits to their society from the high technology air transport industries and establish goals and provide the resources to secure increased shares for themselves. U.S. Industry is being hard pressed to maintain its historical dominance of these markets. NASA has a unique role to play in this international competition and it is our desire to assist them in every way possible to realize the maximum benefit for the U.S. and that is what we would like to address for you here today. This concern, as well as a number of related issues, were evaluated by a multi-agency governmental study group under the chairmanship of the Office of Science and Technology Policy in the Executive Office of the President, and we want to publicly support their recommendations.

They confirmed the importance of aeronautics to national defense and the national transportation system, and recommended a continuation of the government's role in aeronautical research and technology to "ensure the timely provision of a proven technology base to support future development of superior U.S. aircraft," and "a safe, efficient and environmentally compatible air transportation system." The study group noted that the aircraft industry is a major U.S. enterprise. It noted that a major factor influencing the future prospects for U.S. manufacturers is the sustained development and availability of new and advanced technology.

Our technology assessments at McDonnell Douglas convince us that there are large potential payoffs still available from aeronautical research and technology effort spanning the full range of NASA activities from fundamental knowledge gained through basic research to the proof-of-concept or technology validation stage so critical before application can be considered for future military or civil aircraft applications. We believe NASA has a unique capability and a unique responsibility in the area of technology validation and it is in this area that we believe the Fiscal Year 1984 NASA program should be strengthened. We do not want to address the R and T base here today. We do want to say that we believe NASA needs to re-establish Systems programs as it is in this area where NASA may make its greatest contribution through the mechanism of multiple technology programs cooperatively and continuously pursued.

Several key system areas have been identified as having high potential payoff in the downstream years which represent programs that are too high risk, too long in return of capital, or are too expensive for industry to do alone. This is where NASA Systems activities are needed to help keep this country competitive. Previous NASA efforts have done much in developing the base Research and Technology in many areas and work has progressed to the point where industry, in cooperation with NASA, has begun to invest its limited research funds in support of several of these proof-of-concept Systems Programs.

Some of the NASA Systems Programs have been outstanding successes in the past, and have given the latest U.S. civil transports dramatic improvements in fuel efficiency. Many of these programs show promise of even further improvements and need to be continued. Specifically, the Systems programs we endorse and should be included in NASA Aeronautics program are:

Subsonic Aircraft Systems which includes Composite Wing Primary Structures, which deserves our highest priority; Laminar Flow Control, which should be funded to continue the successes demonstrated to date; Active Controls, Supercritical Wing and integration effects of these concepts.

Advanced Propulsion Systems which includes the Advanced Turboprop Program, which should be funded in Fiscal Year 1984 to assure realization of and early flight research program, as well as continuation of the successful Energy Efficient Engine and Advanced Turbofan programs.

Reinstitution of an Advance Metals and Structures Systems program to offer benefits across more than aeronautics where metal matrixes, advanced lithium aluminums and advance metals are just now emerging from the laboratories.

As noted previously the foreign government-industry technical community has established R and D programs in many of these technical areas in an attempt to get ahead of the U.S. industry on future product offerings. We must maintain our momentum in Aeronautics and we look to NASA to help guide us.

These are the principal areas we felt it important to address, and I want to thank the committee for giving us the honor and privilege for being able to focus on these systems studies activities here today.

Thank you.

[The following information was subsequently received for the record:]

DOUGLAS AIRCRAFT CO.,
Long Beach, Calif., May 6, 1983.

Hon. SLADE GORTON,
Chairman, Subcommittee on Science, Technology, and Space,
U.S. Senate,
Washington, D.C.

DEAR SENATOR GORTON: You have asked me to comment specifically about how useful the results have been to industry from the NASA Terminal Controlled Vehicle, now called the Advanced Transport Operating System in the NASA budget.

Enclosed are comments on this subject from our Flight Test and Operations organization which we have discussed with many people in government. We can only speak for the value of this program to the Douglas Aircraft Company where we have our own extensive research capabilities and not for the rest of industry where the TCV could possibly be more useful.

Thank you for asking us for our views, and I am sorry that they are not more supportive.

Sincerely,

ROGER D. SCHAUFELE.

Enclosure.

DOUGLAS AIRCRAFT COMMENTS REGARDING THE TERMINAL CONFIGURED VEHICLE (TCV B-737)

1. From the very beginning of the TCV Program, the return on investment of this program has been qualitative only, and most certainly not quantitative.

2. The Douglas Aircraft Company to date, has yet to derive any major beneftis from this program.

3. One of the main purposes of the TCV Program was to increase airport capability by utilizing the microwave landing system and advanced pilot displays (largely through the use of CRT's).

4. It should be interesting to note, that in the FAA's ten year National Aviation Development Program, which is reviewed yearly, still does not forecast operational usage of the microwave landing system, let alone the capacity increase purported by the TCV Program.

5. A major purpose of the TCV Program was dedicated to complete heads down approach and landing. This type of criterion is and was completely inappropriate for commercial operation, yet the program continued and there is nothing today in the vast future for any commercial airplanes designed or to be designed for this type of maneuver.

6. I should be of interest to note, that the CRT's that are currently in use were independently developed irrespective of the TCV Program.

7. If the budget situation is one that would allow for research for research sake, then having a program like the TCV may be in order.

8. To summarize, it is our position that this program be eliminated for any current or future budget consideration.

DOUGLAS AIRCRAFT CO.,
Long Beach, Calif., April 18, 1983.

Hon. HOWELL HEFLIN,
U.S. Senate,
Washington, D.C.

DEAR MR. HEFLIN: I am sorry I have not responded sooner to your letter of March 25, 1983, but it just arrived in my office on April 12.

Your questions focused on an Advanced Turboprop propulsion system and can be answered quite easily regarding the application and risk status level necessary in order to make that application. We at Douglas have been evaluating the concept in detail since 1975.

The funding level for Douglas to recommend is a little more difficult to answer, since it involves a prioritization of other NASA Systems Technology programs and a redistribution of funding from R&T Base to Systems Technology.

Enclosed are our responses to your specific questions. We appreciate your interest and recognition of the importance of the NASA Aeronautics Budget and want to thank you specifically for asking for our opinions on specific programs. Even though the NASA Aeronautics budget may not be very large in comparison to the overall NASA budget, it is a very important and vital building block for the aeronautics industry and the U.S. in maintaining a national resource competitive in the world marketplace.

Sincerely,

ROGER D. SCHAUFELE.

Enclosure.

Question. Do you view the advanced turboprop as a promising propulsion system for airline needs beginning about 1990 in the very extensive medium size, medium range world transport market?

Answer. The Advance Turboprop Propulsion (ATP) System is a concept that seems to offer considerable fuel savings since it was first investigated in 1975 under NASA sponsorship. Douglas has continued to conduct application studies and has focused on the short-haul market area as a first application where the size of the powerplant engines required would be lowest, being on the order of twice the size of the current production engines. Thea early to mid 1990's timing is the earliest window for the system to enter the operational stage.

Question. When would the required technology demonstration program have to be completed to give your company confidence that it could risk design and development of an airplane incorporating that propulsion system in time to compete for that market?

Answer. In order to achieve the early to mid 1990's time period for an operational system the risk of the concept would have to be reduced to a guaranteeable performance in the 1987 time period. For a guaranteeable performance, a large scale flight test evaluation is required so that the technical issues of blade performance, aerodynamic interference with the aircraft, and acoustic treatment could be fully understood. With the data in hand, a production commitment could be made with a high confidence level in the performance of the total system and would be accepted by the airline user.

Question. Of the $30 million augmentation level for NASA's 1984 R&T budget suggested in your statement, how much would you recommend be allocated to the advance turboprop to realistically support that target date?

Answer. To conduct a large scale flight test in the 1987 time period, a Systems Technology budget in the order of $12 to $15 million would be required. Along with this budget a $5 to $8 million R&T Base budget level is considered necessary to work on the supporting technologies. In arriving at the suggested $30 million augmentation of the NASA Aeronautics budget we considered a significant budget reallocation from Base R&T to Systems Technology and a prioritization on rescoping of many of the Systems Technology Budgets.

STATEMENT OF DR. M. E. SHANK, DIRECTOR, ENGINEERING—TECHNICAL, COMMERCIAL ENGINEERING, UNITED TECHNOLOGIES CORP., PRATT & WHITNEY GROUP

On behalf of United Technologies Corporation, Pratt & Whitney Group, I want to express my appreciation for this opportunity to share with you our views on the adequacy of the Administration's budget request for NASA's aeronautics programs.

To begin, I would like to compliment the Congress for augmenting both the Fiscal Year 1982 and Fiscal Year 1983 NASA aeronautics budgets. Following your actions, the Administration published its new "Aeronautical Research and Technology Policy" report last November.

This document is an excellent and comprehensive statement, drawing from inputs in twenty-two reports prepared by industry and compiled by an able group of government people, from DoD, NASA, FAA and the Department of Commerce, led by Dr. George A. Keyworth, II, Dr. Victor H. Reis and Dr. Louis T. Montulli of the Office of Science and Technology Policy. United Technologies wholeheartedly endorses this new aeronautics policy. Particularly noteworthy quotes from the report are:

"The United States depends heavily on technical superiority of military aircraft . . . Continued strong advancement in aeronautical R&T is essential for national security."

"Large gains are expected from continued aeronautical R&T."

"Aeronautical R&T development activities in support of future military and civil applications are largely common . . . A healthy, competitive civil aeronautics manufacturing industry reduces the cost of providing an essential military industrial base."

In previous United Technologies Corporation testimony before this Subcommittee, Mr. Richard Gamble, Group Vice President of United Technologies and President of our Hamilton Standard Division on March 10, 1982, and I on behalf of Pratt & Whitney on April 1, 1982, supported the case for acceleration of the Advanced Turboprop Program, as well as for funding NASA's aeronautics programs, both in the generic Research and Technology base and in Systems Technology.

Some of the points of previous testimony are worth repeating, particularly since many are reflected in the new "Aeronautical Research and Technology Policy" document.

Aeronautics is second only to agriculture in terms of U.S. exports, and ranks number one in net exports.

Civil aeronautics technology contributes tremendously to military aeronautics products, which in turn represented 40 percent of U.S. defense procurement in the Fiscal Year 1983 budget. There is much evidence of NASA contributions to technology which benefited both commercial and military aviation.

It is imperative that the U.S. maintain its position of world leadership in aeronautics. This will require: (1) enormous private resources to finance high technology ventures, and (2) a continuing ability to stave off government-supported foreign competition through U.S. leadership in technological achievement. Our government and industry must work together, more than ever, to maintain first place.

Of prime importance is the continuing long-term generic Research and Technology base effort to advance the state-of-the-art on a broad front in an evolutionary way. In addition, novel concepts of great promise must be investigated and pursued, when appropriate, to establish proof-of-concept. In the propulsion area the Advanced Turboprop or Propfan is a noteworthy example of this.

Foreign government-supported industries are narrowing our country's once-dominant leadership in aeronautics. Foreign manufacturers are already pursuing turboprop aircraft. The French are already in the fourth year of their own advanced propfan program, with the test of a propfan model planned for 1984. The Russians are predicting that propfan Soviet aircraft will enter service in the 1990's, at the same time or even before the West manages to put a propfan into service.

Timing of the Advanced Turboprop Program is critical. Industry must be ready for the market opportunity expected to occur in the early 1990's when current, aging, short/medium range aircraft will need replacement. Studies have shown that there is a potential swing of $50 billion in trade balance hinging on capturing this market.

Much up-front proof-of-concept work, supported by NASA's Advanced Turboprop Program, needs to be done before the U.S. private sector can undertake a new large turboprop aircraft for production. Given our industry's near-term funding requirements, it is unlikely that U.S. industry could commit funding for this proof-of-concept work in a timely manner. In addition, in order to utilize this technology, U.S. industry, at its own risk, will have to invest approximately $2 billion of its own money to develop a product and sell it against foreign competition on the world market.

The fiscal year 1983 NASA Authorization Bill specifically recommended augmenting the Advanced Turboprop Program, with a flight test-bed research program. As yet there has been no action to implement these recommendations and the program has been omitted from the fiscal year 1984 new initiatives. Further, there are no new programs to develop technology to carry large turbofan engines beyond the Energy Efficient Engine (E^3) Program. Such long-term technology effort is essential to insure continued U.S. leadership in propulsion for future generations of both turbofan and turboprop engines into the next century. Nearly three-quarters of all current aerospace exports are civil and military transport aircraft. Of the 18.5 billion gallons of fuel consumed in 1980 by U.S. aviation, about two-thirds was consumed by aircraft with large engines (defined as over 10,000 pounds in thrust for a turbofan or 7,500 shaft horsepower for a turboprop). It should also be noted that by far, the major portion of the improvements in jet transport aircraft fuel consumption have come from advances in propulsion systems technology. The greatest potential for fuel savings and trade balance improvement derives from aircraft dependent on large engines and their technology.

NASA's Energy Efficiency Engine Program, known as E^3, has provided substantiation of many new propulsion technologies. Many of these have been applied to Pratt & Whitney's PW2037 engine, with 37,000 pounds of thrust, now under development at a cost exceeding $1 billion. When this engine enters service on the Boeing 757 in 1984, it will be the most fuel efficient engine of its type in the world. A major portion of the fuel consumption improvement can be attributed directly to the E^3 Program. To illustrate the competitive importance of that improvement, it means that the engine is approximately five to eight percent lower in fuel consumption than its only competitor for the 757, an engine manufactured in Great Britain. In addition, the E^3 technology is also being applied to the new PW4000 family of engines, with a thrust range of 48,000 to 60,000 pounds, to be certificated in 1986.

PROPFAN RECOMMENDATIONS

In July 1981, NASA submitted an accelerated and enhanced Propfan Program to the House Committee on Science and Technology. This 198 million dollar program was designed to establish technology readiness by 1987 so industry would be able to develop propfan aircraft with 15 percent to 20 percent better fuel consumption than alternative contemporary turbofan aircraft. As I have indicated, industry must be ready for a market opportunity expected in the early 1990's when current short to medium range aircraft will need replacement.

As stated in our testimony last April, the ultimate Propfan fleet could save 5 billion to 6 billion gallons of fuel by the Year 2000, and more than 15 billion gallons of fuel over its service life, when compared to alternative new turbofans.

The only major program now being funded is the construction of the large scale propfan itself. The propfan is an 8- or 10-bladed, highly swept propeller which would enable propeller-driven aircraft to fly at the same speed as present turbofan aircraft. This high speed propeller is certainly the single most important thing to do in this area. However, this alone will not give U.S. industry sufficient technology in other related areas and therefore the confidence to proceed.

In addition to starting a flight test bed program and doing associated cabin acoustics work, there must be additional proof-of-concept programs. These would address such vital elements as the gearbox, pitch change system, propeller/engine control, and the propfan-inlet-compressor integration. Work on the technology of the Propfan itself is insufficient, without proof-of-concept on the balance of the propulsion system.

In our view, there should be about $20 million in 1984 devoted to enhance the program. This level of funding would make up some lost time and establish a credible technology program in line with the market requirement of the early 1990's

LARGE TURBOFAN PROGRAM RECOMMENDATIONS

To assure continuation of U.S. leadership in large turbofan engines, as well as engines for later generation turboprop applications, there should be a follow-on technology program, which we call Advanced Turbofan Research (ATR). Such a program would be evolutionary.

There should be long-term preliminary design studies projecting 10 to 20 years into the future. These are essential if we are to focus on and evaluate very advanced technology concepts. There already are such studies going on at NASA Lewis under the Energy Efficient Engine Program, but their continuation is in jeopardy because the proposed fiscal year 1984 Advanced Turbofan Research Program was dropped from the budget. Not only should these advanced requirements design studies be continued, they should be expanded. Their findings then should be used to plan and guide future basic propulsion research and technology component programs.

Our studies show that a vigorous, on-going technology program could lead to fuel consumption improvements of up to 20 percent for advanced turbofans and as much as 35 percent for the later generation Propfan for the 2000 to 2010 time period. These potential fuel consumption improvements are relative to the levels just established by NASA's E^3 Program.

Pursuit of these studies should indicate where larger proof-of-concept programs should be focused to establish ultimately the technology readiness of new concepts. These concepts could be as effective in preparing the way for future developments as those arising from E^3 and equally effective in maintaining U.S. leadership in the engine field. About $4 million should be made available in fiscal year 1984 to begin the initial phases of the important, far-term advanced turbofan and turboprop conceptual work.

CONCLUSIONS

NASA has traditionally provided a stimulus to the aeronautical industry by supporting high risk proof-of-concept work. This conceptual technology has shown the way for industry to channel its development resources. Past and present testimony before this and other committees has provided evidence of NASA contributions to technology in aeronautics which benefited both commercial and military aviation.

When proof-of-concept technology is available, industry is then able to assess development risks. As I said a year ago before this Committee, American industry has not lost its willingness to accept the responsibilities associated with the development of high technology, advanced new concepts and products for the market. The funds that the U.S. Government invests in aeronautics through NASA represents only 4 to 5 percent of the NASA budget and are highly leveraged.

Following NASA's proof-of-concept work, industry must invest, at great risk, more than 10 times as much of its own money to develop and market throughout the world new products incorporating the new technology. Ultimately the sales of these new products could exceed 100 times the original investment by NASA.

The NACA/NASA long-term partnership with industry in aeronautical research and technology has created an aviation industry in our country whose total output in 1981 exceeded $35 billion, and contributed a positive trade balance of $13 billion.

If the U.S. is to sustain this position, we must maintain our world leadership in civil and military aviation technology. We think that the Administration's "Aeronautical Research and Technology Policy" is both forceful and wholly correct in recommending continues government support for aeronautical research and technology development and for military aeronautical technology demonstration, in the report's words, "consistent with overall government priorities and the availability of funds." NASA's proof-of-concept work and its interaction with industry play a vital role in this process.

[The following information was subsequently received for the record:]

Questions of Senator Heflin and the Answers Thereto

Question 1. Setting aside questions of cost and risk, are the facilities and technical expertise within your corporation adequate to perform all the development effort and proof-of-concept which an aircraft manufacturer would need to enable his company to commit to development of a new transport incorporating your advanced turboprop propulsion system?

Answer. No. However, the facilities and technical expertise exist within the corporation to perform the development of a turboprop propulsion system once the appropriate technology is evaluated in proof-of-concept testing. The elements of technology which have to be evaluated are: Propeller structural integrity; large size reduction gear; fuselage noise treatment; propulsion system interaction (propfan/inlet/engine); and propfan/aircraft aerodynamic integration.

An evaluation of the majority of these elements must include a propulsion and aircraft systems flight evaluation which requires the facilities and expertise of an aircraft manufacturer with the support of an engine manufacturer.

Question 2. Do you believe the existing anti-trust law and regulation would permit your company to select a U.S. airframe manufacturer to collaborate on a proprietary development which would encompass all the relevant technologies that extend beyond the range of your company's expertise?

Answer. We feel that existing anti-trust law and regulation would allow our corporation to collaborate with a U.S. airframe manufacturer to evaluate the relevant technologies identified in the response to question No. 1. These regulations could potentially, however, prevent us from working with a competitor to evaluate separate technology elements related to the propulsion system and sharing results.

Testimony given before the Senate Subcommittee on Science, Technology and Space on April 1, 1982 is relevant to your question.

Wolfgang H. Demisch, (then) Vice President, Morgan Stanley & Co., Inc. when discussing the NASA/industry partnership testified as follows:

Clearly this partnership works, and works well. It does so by efficiently linking NASA's technical talent, the country's best, to the industry's financial, marketing, and manufacturing skills. This separates the two major uncertainties in aerospace development, i.e., will it work and will it sell, and addresses each in the most efficient manner.

NASA is best positioned to address the technical uncertainties inherent in aerospace, the "will it work" part. Its infrastructure is the best in the business, and its personnel have the best overview of the technical options available to solve problems most efficiently. NASA can interact freely with both industry and the academic world. It receives problems and data both from the military and the commercial areas, and can cross fertilize between the disciplines in ways impossible to industry, where airframes, propulsion, and subsystems are generally split among several companies, which are mutually competitive, rather than positioned to share their insights or problems. Indeed, anti-trust restrictions would forbid such sharing.

Dr. M. E. Shank, Director, Engineering-Technical, P&W Commercial Engineering, testified:

It is imperative that the U.S. maintain its position of world leadership in aeronautics. This will require (1) enormous private resources to finance high technology ventures and (2) a continuing ability to stave off government-supported foreign competition through U.S. leadership in technological achievement. Our government and industry must work together, more than ever, to maintain first place.

NASA has traditionally provided a stimulus to the aeronautical industry by supporting proof-of-concept work.

Question 3. If you were legally free to proceed in that fashion, would there still remain a vital role for NASA or any of its aeronautics research centers in the development and demonstration of advanced turboprop technology?

Answer. NASA's role is vital in providing the coordination and management of a proof-of-concept program needed to bring advanced turboprop technology to fruition.

OSTP published a report in November, 1982, titled "Aeronautical Research and Technology Policy," which identified national goals in aeronautics. For aeronautics R&T, the report stated that the role of NASA is to "Ensure the timely provision of a proven technology base to support future development of superior U.S. aircraft." NASA's effort on the turboprop clearly addresses this goal. Not only is early funding support necessary, but perhaps more important, with NASA coordination and management role "linking NASA's technical talent, the country's best to the industry's financial, marketing, and manufacturing skills * * * NASA can interact freely with both industry and the academic world" (1) and with their guidance, the technological risks can be minimized such that the enormous investment in propfan and propfan powered aircraft development can be made by U.S. industry with assurance of continued successful dominance of the world aircraft market.

(1) Reference Demisch testimony of Question No. 2.

STATEMENT OF ROBERT C. HAWKINS, MANAGER, ADVANCED TECHNOLOGY OPERATION, AIRCRAFT ENGINE BUSINESS GROUP, GENERAL ELECTRIC CO.

Mr. Chairman, my name is Robert Hawkins and I am the the manager of the advanced technology activities of the General Electric Aircraft Engine Group. We welcome the opportunity to appear here today.

There are several points that I would like to reinforce. We enjoy excellent relations with NASA at all levels in the planning and execution of aeropropulsion research programs. NASA gives us adequate opportunity to make our views known during the program formulation process and acts on those views in a responsive way. Therefore, we see no reason to reorder the program that NASA has presented to you within the stringent budget constraints placed upon them. The budget as presented will permit NASA and the aeronautics industry to make significant gains in technological capability. However, there are many other significant opportunities for advances that will not be exploited because of the tight budget constraints. Significantly greater budget authority will be required to exploit just the more critical of these opportunities for further advances.

Furthermore our analysis of the NASA and DOD budgets show a continuing decrease in the level of total government support for aeropropulsion research. This trend is particularly pronounced in work on subsonic transport propulsion systems. Such continued decline can only result in a deterioration of the U.S. pre-eminent position in aeropropulsion.

I would like now to offer a few comments on some of the opportunities that will not be exploited by this minimal NASA budget.

1. The Energy Efficient Engine program is a major milestone in aircraft engine technology. We have completed very successful tests on the core or high pressure section of the engine and will begin testing of the complete E^3 engine next month. In spite of the outstanding success of this program the NASA budget does not permit the funding of follow-on work to improve further the turbofan engines of the future and to extend the E^3 technology base.

2. Turboprop research has been fostered by this subcommittee and now the NASA efforts are showing very great promise. We endorse a broadening of the scope of the ground test program to include a broader range of advanced turboprop concepts such as counter-rotating systems. Turboprop research is now beginning to blossom and we should continue to push forward the technology on the broadest possible front.

3. Rotorcraft are increasingly important in military and civil applications. The state of development of rotorcraft is not nearly so advanced as it is for fixed-wing aircraft. That is true for the engines for these vehicles also. There are opportunities for significant gains in the component efficiencies of the various components of the engine designed for rotorcraft use.

4. Laminar flow research, although focused primarily on airframes, will also benefit installed propulsion system performance with the use of nacelles designed to maintain laminar flow and thereby to reduce aerodynamic draft.

In conclusion I want to reiterate first—our support for NASA's program as submitted to the Congress, second—our concern at the continued decline in overall government support of aeropropulsion research and third—the GE view that there are many excellent opportunities for technology advancements to improve the performance of propulsion systems that are not funded in NASA's or DOD's budgets as submitted.

Thank you, Mr. Chairman.

[The following information was subsequently received for the record:]

GENERAL ELECTRIC,
AIRCRAFT ENGINE BUSINESS GROUP,
Cincinnati, Ohio, April 19, 1983.

HOWELL HEFLIN,
Ranking Member, Subcommttee on Science, Technology and Space,
U.S. Senate, Washington D.C. 20510

DEAR SENATOR HEFLIN: Thank you for the opportunity to respond to your questions regarding turboprops and the numerical aerodynamic simulator.

With respect to your first question on turboprops, let me point out that General Electric has been engaged in development and production of drive systems for helicopter rotors for quite a long time. The most recent engine that we have developed is the T-700, and we are in the process of certifying a turboprop derivative of this engine, which we call the CT-7. The CT-7 is planned for use as a turboprop propulsion system on commuter aircraft. We expect to continue to provide turboprop propulsion systems for a variety of aircraft. We anticipate that as technological advances are made by NASA, ourselves, and other industry groups, that turboprop propulsion systems will prove to be efficient on an ever broader range of aircraft.

We have participated frequently with NASA over the past eight years, in the formulation and advocacy of advanced turboprop technology programs, and feel that all of industry will use whatever valid results are generated by the program.

With respect to your second question, NASA's program for a mumerical aerodynamic simulator (NAS) represents a major effort to accelerate efforts to increase the utility of the advanced computers in describing external (airplane) and internal (engine) aerodynamics. At General Electric we are increasing our use of the computer for many design and development tasks. Indeed, this is one of the major thrusts of our advanced engineering activities. We expect that the successful implementation of the numerical aerodynamic simulator program by NASA will have major benefits to General Electric and the aeronautics industry. We expect that there will be a steady stream of software advances that we will be able to utilize as early as one year after NAS project initiation.

Sincerely,

R. C. HAWKINS.

GENERAL ELECTRIC,
AIRCRAFT ENGINE BUSINESS GROUP,
Cincinnati, Ohio, April 19, 1983.

Mr. SLADE GORTON,
Chairman, Subcommittee on Science, Technology and Space,
U.S. Senate, Washington, D.C.

DEAR SENATOR GORTON: Thank you for the opportunity to expand further on our testimony to the Subcommittee on Science, Technology and Space.

I am repeating your questions to us followed by our responses.

What work is being done in the Advanced Turbofan technology by private industry?

The General Electric Aircraft Engine Group is in the final stage of the NASA Energy Efficient Engines (E^3) program. In that program we have demonstrated a number of advanced concepts which together can result in fuel consumption improvements in the range of 10–15 percent, depending upon the kind of mission. A 10–15 percent improvement is a major step forward in turbofan technology. In addition, we now see the possibility of further advances in engine technology which will permit the historical rate of engine improvements to be sustained through another generation of aircraft engines. This steady rate of improvement is threatened by the downturn in NASA funding for advanced turbofan technology. NASA has assumed a leadership role within the federal government for technology advances in transport engine technology. It is very important that NASA be permitted to sustain its support of the transport engine industry with adequate funding from the Congress.

Is the development of the Advanced Turbofan critical to the civil aircraft industry now?

The lead time from initial concept to application in transport engines is five years or more. Our business projections lead us to conclude that the next round of new transport engine developments will occur in the late 80's and early 90's. With this timing of new products it is imperative that technology advancements be pursued vigorously now so that these advanced ideas will be proven and ready for use in the next generation of engines expected at the end of this decade.

What benefits would the air transport industry receive from a serious level of effort by NASA in Advanced Turbo technology?

A serious level of effort by NASA in Advanced Turbofan technology will permit the development of advanced concepts and an adequate amount of testing to elucidate problems and their solutions. With this information in hand, the engine manufacturer can decide to incorporate these advanced concepts into a new engine product developments with an adequate basis of concept verification and hence, with a minimum of technical risk. Successful incorporation of advanced concepts will result in the availability of new, more efficient engines. Their decreased cost of operation will result in lower fares and hence, increased travel demand. Increased travel demand means more jobs and other economic benefits. Technology advances of the past have created advantages for the traveler, the airlines and the manufacturers of airplanes and engines. Future technology advances will generate similar benefits.

Thank you for the opportunity to respond to your questions. My staff and I are prepared to work with you and members of your staff in assuring adequate funding for the NASA aeronautics program.

Sincerely,

R. C. HAWKINS

STATEMENT OF H. W. (BOB) WITHINGTON, VICE PRESIDENT, BOEING COMMERCIAL AIRPLANE CO.

Mr. Chairman and members of the committee, my name is Bob Withington—Vice President of the Boeing Commercial Airplane Company. We appreciate the opportunity to present our views on the important subject now before the Committee—the fiscal year 1984 NASA Aeronautical Program.

Last year at this time, the Executive Office of the President—Office of Science and Technology Policy (OSTP) was chairing a multi-agency study group formed to review national aeronautical R&T policy. The November 1982 report issued by the study group contained several findings that generally recognized the commonality of aeronautical R&T needed for the military and civil sectors, and the importance of such research to our national security and the economic benefits to our nation from a healthier U.S. civil aeronautical industry. With regard to the U.S. Government role, the report contained the recommendation for; "Government support for aeronautical R&T development and for military aeronautical technology demonstration, consistent with overall government priorities and the availability of funds." It was also recommended that NASA fund, direct and implement aeronautical R&T development programs and support military aeronautical technology demonstration programs. Issuance of the report and its endorsement by the President's Scientific Advisor indicates Administration concurrence with the content.

Considering the findings and recommendations made by the OSTP study group, we would expect to find a reversal of the decay that has occurred over the past several years, in the real dollars made available for NASA to carry out their responsibility. The fiscal year 1984 program does not meet that test. For the total aeronautical budget, the very nominal increase over fiscal year 1983 accounts for little more than inflation. We are particularly concerned about the significant reduction in the systems technology budget for fiscal year 1984 as compared to fiscal year 1983. The complete lack of funds for Advanced Transport Operating Systems, Advanced Control Systems, Advanced Turboprop, Laminar Flow Control, and IPAD (Integrated Programs for Aerospace-Vehicle Design) programs, shows a negative, rather than a positive response to determinations made by the OSTP. In each case, NASA and industry have had productive work underway. That momentum will be lost if they are dropped. It was clear that the study group recognized the high cost and risk of such R&T development programs and intended that they be pursued by the NASA.

Mr. Chairman, we strongly recommend this committee take action to ensure adherence to the intent of the OSTP Aeronautical Research and Technology Policy.

I would like to note that the NASA has developed an effective process aimed at defining short and long term programs having proper balance between and within major research categories, and within realistic resource requirements. This process is in the form of advisory groups made up of high level, qualified representatives of industry, government and academic organizations that advise and comment on NASA planning. The pros and cons, and the relative merits of individual and collective R&T development efforts planned by NASA are discussed with consensus recommendations being provided by those that will be most affected by results of the research. This is done in an atmosphere where the varied interests of affected parties have equal opportunity to be reviewed on a relative basis. This is in contrast to issues being presented by vocal, single issue groups without assurance of consideration for equal, or more important issues. The NASA has in turn been quite responsive to advisory group recommendations, with productive programs being the result. This process was used prior to submittal of the NASA fiscal year 1984 plan to the Office of Management and Budget (OMB). Unfortunately, it was not possible to do so after subsequent revision of the plan.

On April 1, 1982, I appeared before this committee and noted that foreign competition is very real and a significant challenge to this country in both the military and civil sectors. The civil competition remains very fierce with a reduced market caused by the worldwide recession. Sales have diminished with a decreasing capability to fund the needed research. The employment posture of a significant portion of this country's workforce is at stake over the short, as well as the long term. Adherence to what we understand to be the intent of the OSTP policy would provide needed assistance toward meeting the challenge. Again, we strongly urge this committee to correct what we believe is deviation to the policy intent.

It has been a privilege to be asked to appear before this committee. Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. Mr. Withington, the Boeing testimony includes a statement that the elimination of funding in fiscal year 1984 for Advanced Transport Operating Systems was not in line with the Administration's policy on aeronautical research and technology. What benefits would the air transport industry gain from this program?

Answer. The elimination of funding in 1984 for the Advanced Transport Operating Systems would delay the needed research and development work on many promising potential technical improvements that we feel could improve our national competitive position in the production of large transport aircraft. Our competitive position with respect particularly to the French Aerospatiale organization is very much a function of the technical excellence of our product. We have had to accept that financial and political support from particularly the French Government is something that we are not able to match. Therefore, our only basis for a superior product is in the technical area. These new Operating Systems Technologies, which were being funded, would assist U.S. industry in maintaining the slight current technical advantage that we now enjoy. Failure to support these programs puts that possible advantage at risk.

Question 2. Is this a program that private industry could or would take over?

Answer. Essentially all of the programs involved in the Advanced Transport Operating Systems were ones that most of the U.S. industries (certainly Boeing) were working on with company funds. However, the generally depressed condition of our industry at this time severely limits the magnitude of the funds available to bring these new technologies up to the point of production commitment. We certainly intend to continue working in these areas. However, the limited company funding will extend the time at which these new technologies can be available, therefore increasing the risk of losing what slight technical advantage we currently enjoy. These programs, in the past, have been cooperative between industry and government. I am convinced industry is doing the best it can under the current business environment. The additional funding that was planned to be provided by the government would have helped us maintain the technical superiority of our products. I am sure you are well aware that the overseas sale of large commercial aircraft is one of the very few areas which provide a favorable balance of trade.

STATEMENT OF JOHN E. RALPH, SENIOR VICE PRESIDENT—OPERATIONS AND TECHNICAL SUPPORT, AIR TRANSPORT ASSOCIATION OF AMERICA

This statement presents the views of the member airlines of the Air Transport Association on NASA aeronautical research and NASA's fiscal year 1984 budget.

For many years the airlines have supported a vigorous NASA Aeronautical Research and Technology Program. This support has been based both on NASA safety-related work and on aircraft and engine technology work. NASA safety and human engineering programs hold promise of improving the level of safety in aircraft operations, a vital objective in view of the fact that safety is our paramount concern. With respect to technology, the airlines operate aircraft and engines which have been designed from established technologies, and are limited by the efficiencies and cost of operation dictated by these technologies. NASA has addressed the fundamentals of these limitations with potential for significant improvements in efficiency.

Over the past several decades, NASA and its predecessor, the National Advisory Committee on Aeronautics (NACA), have an undisputed record of success in providing advances in the technology base that provides the underpinning support for a viable U.S. air transport system. These advances have fostered the manufacture of aircraft which are the world's standard, and have contributed significantly to the nation's balance of payments as a result of our leadership in worldwide aircraft sales.

This past year the Administration revalidated the important role of NASA aeronautics programs by adopting the Keyworth Report, the Aeronautical Research and Technology Policy, in November 1982. Also during 1982, the National Research Council reviewed NASA programs and identified a number of areas where additional work is necessary. Unfortunately, it appears the new policy came too late to significantly influence the budget sent to Congress for fiscal year 1984. We are hopeful, however, that the fiscal year 1985 budget will provide for a more aggressive approach to the needs of civil aviation.

At this time, we see a need for NASA Aeronautical Research and Technology Programs to include continued emphasis on safety and improved service durability of systems, as well as energy efficiency. We are pleased that present efforts included under the energy efficient transport and the energy efficient engine programs indicate the potential for significant improvements in reliability and maintainability in addition to their fuel conservation benefits. We believe these efforts need to be pursued further in related projects such as the Advanced Turbo Fan Program and others. We also believe there is room for continuing advancement in both the metallic and non-metallic materials field, and that further exploration of advanced stability concepts is necessary to permit lighter weight aero structures in the near future.

We support the application of the human engineering discipline to advanced automated airborne systems as a means to improve safety and operating efficiencies. It is noted that the Administration proposes to eliminate the funding for the Advanced Transport Operating System (ATOPS) program. In these austere times this action is probably necessary and we are not suggesting its resurrection; however, steps should be taken to retain some of its supporting facilities which may be useful for other efforts.

We are concerned that manpower limitations may stand in the way of achieving the full potential of NASA Aeronautical R&T Programs. Notwithstanding statements about hiring young engineering graduates, it appears that NASA has been placed under a personnel ceiling, which is likely to cause a reduction in the number of experienced and qualified personnel in the NASA Research Centers. We are hopeful that steps can be taken to rectify this situation.

In summary, we are pleased about the announcement of a new aeronautical research and technology policy, and are looking forward to an invigorated NASA program for civil transport aircraft in fiscal year 1985. In this regard we enthusiastically support the need for NASA work leading to safety, durability and efficiency of civil air transport aircraft and systems.

Senator GORTON. We will now hear from Mr. Edward Stimpson, president of the General Aviation Manufacturers Association.

STATEMENT OF EDWARD W. STIMPSON, PRESIDENT, GENERAL AVIATION MANUFACTURERS ASSOCATION

Mr. STIMPSON. Thank you, Mr. Chairman. We appreciate the opportunity to testify this morning on behalf of the 35 companies in our association which manufacture everything from intercontinental business jets to commuter airplanes to small, twin-engine trainers and agricultural aircraft. Our industry has enjoyed a very productive relationship with NASA over the last few years and its laboratories at Lewis and Langley and other places. Many of the developments that have occurred there are now on our airplanes. It is certainly a most productive and profitable venture.

Research and development have long been important to our industry. Until recent years, our competition came primarily from within our own ranks, and new technology applications often had a significant impact in our marketplace. Our manufacturers have historically invested about 5 percent of their sales in R&D and they continue with a substantial commitment today.

However, the effects of the recession over the past few years have also affected R&D dollars and have gone down with decreases in our sales which were down 30 percent last year. Unit deliveries have declined about 75 percent over the last 3 years. During this same time, competition from foreign manufacturers, especially in the business jet and turboprop area, have increased significantly.

Aided by strong support from their governments, from capital investment to R&D funding to export finance subsidies, these competitors have taken aim at the U.S. market and have enjoyed an incredible degree of success.

About 60 percent of their total sales are right here in the U.S. market. Of all business jets sold last year in the United States 43 percent were foreign manufactured, and in the 10-to-19 passenger category of aircraft, turboprop, about 50 percent of the sales were by foreign manufacturers. This is more than just a challenge to our industry. It constitutes a serious threat to our national pride and leadership in aviation.

And, Mr. Trible, I was pleased to have you get into this business about technology transfer and release of NASA information this morning. It is a problem and I am not sure I have any answers for you today, but it is certainly a question that we need to explore a lot more.

The long-term effects of such market penetration, especially if sustained, are not hard to postulate. Already, the toll on employment in our industry has reached a record level. The positive balance of payments contributed for years by our industry became a trade deficit in 1981, and continued to 1982 when total import dollars exceeded our exports.

On technology, continuing development, research and engineering have brought new technological advances that will lead customers to the marketplace. Despite the recession, we have seen announcements of new airplanes—cabin class singles and single engine turboprops. Our goals are efficiency and speed. We have seen single-engine piston cruise speeds over 200 knots, twin engine piston speeds of 300 miles per hour, single engine turboprops cover 350 miles per hour, and turboprop twins topping the 400 mile per hour mark. Meanwhile, some of our new jets are flying 10,000 feet above the airlines, avoiding the airway congestion while operating at very high efficiency and outstanding performance. We think all of these bode well for our industry in the future.

Now, the White House Office of Science and Technology Policy statement released in November is most encouraging. Overall, we think it is a forthright and constructive statement. The conclusion that continued research in aeronautics is in the national interest is particularly welcome in view of past attempts to deemphasize aeronautical research. This White House acknowledgement of the importance of Government-sponsored R&T is most timely.

Now, there is a finite limit as to what our individual companies can do. With a dramatic increase in foreign Government-supported competition from abroad, we believe the U.S. Government will continue or must continue to play a vital role. Given the unique and superb NASA facilities and their capabilities and expertise, we believe we can outpace our competition if we fund and go ahead with the necessary programs and R&T.

As we review the NASA budget in the area of aeronautical research and technology, we are encouraged. The budget was slightly increased. At the same time, we find some of the reductions are hard to understand when you look at the overall conclusions and recommendations of the OSTP study. We are particularly concerned that most of the projects which appear to have the greatest potential for our industry in general aviation seem to have been reduced dramatically or zeroed out.

According to NASA, the budget request before you includes about $7.1 million for the general aviation sector. Now look at some of the individual programs, briefly, in the advanced turboprop system, which involves research in high speed 0.8 mach number propeller. We believe this is an important program, and to remain competitive worldwide, this technology is very important to us. As you know, Congress recognized this last year by adding additional money to the budget.

Another program which is of extreme importance to us is the small engine component technology. There are tremendous gains in performance, efficiency, reliability, noise and emission levels that we have seen in larger engines, and it underscores the great potential for improvement in small engines. This is an area which is again receiving priority attention by our overseas competitors. The $4 million request is a modest sum to initiate a program that can pay big dividends in the foreseeable future, and we would certainly hope the committee would consider putting this back into the budget.

The broad property fuels area—this is another program which was funded by Congress last year. It explores the question of synthetic alternate fuels for use in aircraft powerplants. We should not let a temporary fuel glut this year wipe out the recognized need to look to the long-term availability of fossil fuels and consider alternatives.

Composite structures are very important for our industry as well as for the larger transport industry. We see more composites going on airplanes every day, and the gains to be achieved in fuel efficiency and operating performance are very important.

Now, we are not always talking in general aviation about big expensive programs, Mr. Chairman. Yesterday, a program was brought to my attention which has a lot of merit. The program is being developed at Wallops Island, at relatively low cost within NASA.

Last year, we had about 80 accidents in general aviation because of water in the fuel, fuel contamination. Normally now, a pilot goes out and, using this device, he gets fuel out of the bottom of his tank and he looks at it. If it looks like water is in it, he thinks he has a problem. If it is all clear, he dumps it and goes on.

But NASA, after looking at the actual statistics—and we have a lot of work going on in aircraft and their fueling right now—came forward with a proposal that said well, I think in NASA we can do some research which will help identify within the fuel whether there is water, particulate structure or whatever. And they are going ahead with this project.

As I say, with an insignificant amount of money they may have a great breakthrough here which could save some 80 accidents a year. So as we talk about the NASA budget, I think it is important that we focus on the small dollars as well as the big dollars, because they have a lot of things going on within the NASA programs that can achieve real results in safety as well.

So, Mr. Chairman, I have attempted to review with members of this committee, the very serious challenges facing our industry in view of the highly competent government-subsidized competition we are seeing from our foreign manufacturers. It is difficult to undertand why some of these programs are being reduced to token levels in the budget-cutting process. We believe our industry is a national asset which for many years has set the general aviation standards throughout the world and has annually contributed, until recently, a positive trade surplus to our Nation's balance of payments.

We are being victimized by our foreign competition that generally subsidize their aviation industries to create jobs and increase their market share around the world. And one important area in which the U.S. Government can contribute to the vitality of the aviation industry is in research and technology. It is obvious that it is up to the Congress and this committee to take the necessary actions to achieve this goal.

Thank you very much for your attention.

Senator GORTON. Would you outline for me what you would consider to be the respective responsibilities of the general aviation industry on the one hand and NASA on the other hand to help the industry achieve the level of excellence and dominance that it did a few years ago?

Mr. STIMPSON. Well, I still think we have the excellence and dominance. I think we are being matched from abroad now because they have good technology abroad, as good as we have here. The things that NASA, I think, can do most effectively and be most helpful in is the utilization of its facilities and its expertise and its personnel in some of these programs we have talked about here today where the U.S. industry does not either have the research dollars to do this now or that NASA has had other work going on. We get a lot of fallout also from some of the programs that you heard described by the large transport people today.

Now, sometimes these economies of scale can be transferred down to our programs. Sometimes they cannot. For example, the small engine program that we talked about today. It is very difficult to take what they have done in the large engines and put it in the small engines. This is one area where—and this is why we put such a high priority for NASA proceeding with this.

So I would say in answer to your question, Mr. Chairman, some of these programs which are beyond us to undertake from a risk sharing ability right now are those where NASA has the expertise through their facilities.

Let me give you another example. A few years ago at Langley, NASA bought a bunch of airplanes that had been damaged in the flood at Piper Aircraft. Using their lunar landing apparatus, they took these airplanes and they crashed them one after another, and we learned some very valuable information from these crash tests, information which is now going into some of our airplane designs. None of us have that sort of facility in any of our plants anywhere throughout the country (throughout the world, for that matter) to crash airplanes from an altitude and get that sort of information. So I think it needs to be a well-defined program.

In the past we have been very critical of NASA when they get into programs that we do not think they should be in, where we are doing it ourselves. We say please stay out of that. We do not need your help in this program. Or they can help us in programs of this type, and we certainly encourage it.

Senator GORTON. Thank you. Senator Trible?

Senator TRIBLE. In your judgment, what is the primary reason for the success of our foreign competitors in the general aviation area of late? And what is private industry doing to regain its preeminent position?

Mr. STIMPSON. Well, I think the success has been their determination to get into the aircraft manufacturing business, the ability of their governments to finance every phase of research, design, production, and then help finance their products abroad, and they consider it a top priority national project. And they have selected their marketplace, like the turboprop commuter aircraft market, or the business jet market. They have been selective in selecting their markets, and they have done well.

And I think the challenge we face is to keep our technology ahead and make sure we do not fall behind in technology. And second, we have some very serious trade problems, and I know we are not talking about trade today, but there is the issue of unfair trade practices where they have been able to penetrate our markets with sweetheart financing deals financed by their governments. That has been another very real reason why they have proceeded to penetrate our marketplace with such success.

[The statement follows:]

STATEMENT OF EDWARD W. STIMPSON, PRESIDENT, GENERAL AVIATION MANUFACTURERS ASSOCIATION

We appreciate the opportunity to testify before this subcommittee on the adequacy of the Administration's 1984 budget request for aeronautics. the 35 companies in GAMA manufacture 95 percent of the aircraft, engines and component parts used in general aviation. General aviation aircraft are the intercontinental business jets flying faster than airliners, the commuter aircraft that now serve many of our cities, and turboprop and piston engine-powered aircraft serving business and personal transportation needs.

Research and development have long been important to our industry. Until recent years, our competition came primarily from within our own own ranks, and new technology applications often had a significant impact in the marketplace. Our manufactuers have historically invested about five percent of their sales dollars in R&D, and they continue with a substantial commitment today.

However, given the debilitating effects of world-wide recessionary economies over the past few years, the total R&D investment dollars have decreased with our sales which were down 30 percent in 1982. Unit deliveries are down 75 percent from three years ago.

During this same period, competition from foreign manufacturers—especially in the business jet and turboprop classes—has increased significantly. Aided by strong support from their governments—from capital investment to R&D funding to export finance subsidies—these competitors have taken aim on the United States market, and have enjoyed an incredible degree of success: about 60 percent of their total sales are made here. Forty-three percent of all the business jets and 50 percent of the 15-19 passenger turboprops sold in the United States last year were manufactured by foreign firms. This is more than just a challenge to our industry; it constitutes a serious threat to our national pride and leadership in aviation.

The long-term effects of such market penetration—especially if sustained—are not hard to postulate. Already the toll on employment in our industry has reached record levels. The positive balance of payments, contributed for years by our industry, became a trade deficit in 1981 and continued through 1982 when import dollars exceeded exports.

TECHNOLOGY

Continuing development, research and engineering have brought new technological advances that will lead customers to the marketplace. Among them are new pressurized, cabin-class singles and single engine turboprops. Our goals are efficiency and speed: single piston engine cruise speeds over 200 knots; twin engine piston speeds of 300 miles per hour; single engine turboprops covering 350 miles per hour and turboprop twins topping the 400 mile per hour mark. Meanwhile, our new jet designs are flying 10,000 feet above the airlines, avoiding airway congestion while operating with very high efficiency and outstanding performance. All of these technological advances bode well for a strong, product-oriented recovery. Facilities and plants have been or are being modernized or expanded at a number of locations to meet future demand.

The White House Office of Science and Technology Policy (OSTP) statement released in November 1982 is most encouraging. Overall, we think this is a forthright and constructive statement. The conclusion, that continued research in aeronautics is in the national interest, is particularly welcome in view of past attempts to deemphasize the federal government role in aeronautical research. This White House acknowledgment of the importance of government-sponsored R&T is most timely, especially for our industry. There is a finite limit as to what our individual companies can do and, with the dramatic increase in government-supported competition from abroad, the U.S. Government has a vital role to play. Given the unique and superb NASA facilities, computer capabilities and expertise, the U.S. can outpace the competition if the necessary programs are adequately funded.

As we review the NASA budget request in the area of "Aeronautical Research and Technology," we are indeed encouraged by the $63.9 million increase over the 1983 estimate. That encouragement is short-lived, however, when we examine the Administration budget and find that NASA's request has been adjusted downward by $43.6 million. The reductions are hard to understand when one considers the findings in the OSTP Study and the competitive success our trading partners are enjoying in our marketplace with their technologically sophisticated airplanes. We are particularly concerned that most of the projects which appear to have the greatest potential for the general aviation industry have been reduced or zeroed out. Accordingly to NASA, the budget request before you includes only $7.1 million for the general aviation sector.

ONGOING SYSTEMS TECHNOLOGY (REDUCED FROM $60.2 MILLION TO $39.5 MILLION)

Included in this group is the Advanced Turboprop System which involves research in the high-speed, .8 mach number propeller; the entire $8.7 million original NASA proposal has been eliminated. To remain competitive world-wide, this technology is very important. The Congress recognized the importance of this program in 1983 by adding $15 million after the Administration had zeroed out the program. We ask that this Committee take similar action in 1984.

SMALL ENGINE COMPONENT TECHNOLOGY (REDUCED FROM $4 MILLION TO ZERO)

The tremendous gains in performance, efficiency, reliability, noise and emission levels we have seen in larger engines underscore the great potential for improvements in small engines. This is an area receiving priority attention by our overseas competitors. The $4 million requested is a modest sum to initiate a program that can pay big dividends in the foreseeable future. The $4 million originally programmed would be the first installment on a 5-year, $50 million effort that we strongly support.

BROAD PROPERTY FUELS ($0 REQUESTED)

This is another program funded by the Congress at $3 million in 1983 but eliminated in 1984. It explores the question of synthetic, alternate fuels for use in aircraft powerplants. We should not let a temporary fuel glut this year wipe out the recognized need to look to the long-term availability of fossil fuels and consider alternatives.

COMPOSITE PRIMARY A/C STRUCTURES ($0 REQUESTED)

This program has great potential for the general aviation industry, and another one which the Congress funded in 1983 despite a zero budget request. The Administration has again sent to the Congress a zero budget request for 1984. The importance of composites to the industry is underscored by major, on-going, company-funded projects. Nonetheless, the support of NASA in this new technology area is vital to its development and we encourage the Congress to provide funds in 1984 again as they did last year.

Mr. Chairman, I have attempted to review with the members of this Committee the very serious challenges our industry faces from a growing number of highly competent, government-subsidized foreign manufacturers. It is difficult to understand why general aviation research and technology is reduced to a token level of effort in the budget-cutting process. The industry is a national asset which for many years set the general aviation standards the world over, and annually contributed a trade surplus to our nation's balance of payments. This situation has changed radically in the last two years. We are being victimized by foreign governments that generously subsidize their aviation industries to create jobs and increase their market share around the world. One important area in which the United States Government can contribute to the viability of its aviation industry is in research and technology. It is obvious that it is up to the Congress to take the necessary actions.

Senator **Trible** [presiding]. I thank you very much for your testimony today, and I can assure you that this committee is going to do all it can to provide an adequate measure of support for the general aviation industry through the important activities of NASA. Thank you, Mr. Stimpson.

Mr. **Stimpson**. Thank you very much, Senator Trible.

Senator **Trible**. OK. Next we will have a Space Shuttle and fifth orbiter panel. Dr. Klaus Heiss, Dr. Michael Yarymovych, and Dr. Stanley Rosen. And anyone else you might have with you that you wish to bring forward.

Welcome, gentlemen.

STATEMENTS OF DR. KLAUS P. HEISS, PRESIDENT, SPACE TRANSPORTATION CO., INC.; DR. MICHAEL I. YARYMOVYCH, PRESIDENT, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, VICE PRESIDENT, ADVANCED SYSTEMS, ROCKWELL INTERNATIONAL; AND DR. STANLEY G. ROSEN, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, CHAIRMAN, SPACE SYSTEMS TECHNICAL COMMITTEE

Dr. **Yarymovych**. Mr. Chairman, my name is Michael Yarymovych, I appear here as president of the American Institute of Aeronautics and Astronautics. The AIAA is a nonprofit technical society with over 34,000 members who are engineers, scientists and students engaged in every sector of the aerospace profession from industry to Government to the universities.

The institute's professional membership is divided into 68 sections around the country. To further scientific and technical advancement, we have 51 technical committees covering every aspect of the aerospace profession. Our testimony today does not necessarily represent a consensus of our membership anymore than one administration is a perfect representation of the will of all the people. Our testimony represents the expertise of a select group of our members who were given this responsibility by me in my capacity as president of the institute. We welcome the opportunity to offer an outside perspective on our Nation's role in space.

As we observe the 25th anniversary of NASA, we recognize the need to build on our heritage and to maintain a balanced and dynamic civil space program within the fiscal constraints of the 1980's.

As we have consistently reported to the subcommittee in the past, the NASA program is, in our opinion, the wrong slice of the Federal budget in which to trim our Nation's relatively modest ongoing investment in research and development.

To this end, last year we generally endorsed the level of NASA space activity proposed by the administration while pointing out several areas where an increased investment was justified. We commend this subcommittee, as well as the entire Congress, for appropriating more resources for NASA than were originally requested.

As President Reagan clearly recognized in his state of the Union address, we live in a country ever more dependent on technology for its strength and survival. We therefore feel confident that there are few ways to better invest in the Nation's future than in the space program, an area which today commands a relatively small portion of the Federal budget.

For this reason, as well as others expressed in our written statement, we are compelled to advocate a more vigorous civil space program for fiscal year 1984 than that which has been proposed by the administration.

One of the key components of our national space program is, of course, the space transportation system. In your invitation to us to appear before this committee you specifically asked us to address ourselves to issues regarding the Space Shuttle, including the need to procure additional orbiters, and our assessment of the market for Space Shuttle operations.

Whereas our submitted statement contains detailed commentary on all aspects of the proposed NASA budget, we will confine our brief remarks here this morning to the subject of the Space Shuttle.

First, Mr. Chairman, I would like to point out that the AIAA issued a paper detailing our view of U.S. national space policy in May 1982. I would like to submit the full paper for the record.

Senator TRIBLE. It will be made part of the record of these proceedings.

Mr. YARYMOVYCH. Thank you.

Two areas of that paper specifically addressed the Space Transportation System. First, we recommended that it should be a goal of the U.S. space program to, and I quote, "achieve routine access to space through continued commitment to an operational space transportation system sized to meet both current and projected needs for defense, commercial, science and foreign users."

To accomplish this goal, we further recommended that the United States should "continue and expand the evolutionary development of a versatile operational space transportation system adequate to support projected traffic demand, incorporating elements to improve the efficiency and reduce the cost of carrying freight and personnel not only from the Earth into orbit but also between various Earth orbits and other trajectories." And "should initiate procedures to determine the optimum operational mode for the space transportation system once it has been fully developed and demonstrated."

Mr. Chairman, these statements summarize our view of the proper U.S. policy regarding the space transportation system.

I would now like to introduce Dr. Stanley Rosen, on my right, chairman of our technical committee on space systems, who will elaborate on the implications of these space policy recommendations for the fiscal year 1984 NASA budget.

Senator TRIBLE. Dr. Rosen.

Mr. ROSEN. Thank you, Dr. Yarymovych.

Mr. Chairman, we of the AIAA are pleased that your subcommittee has taken a special interest in the Space Shuttle program. This new capability, whose development has undoubtedly been an arduous technical and managerial challenge, is in fact maturing rapidly. Although we recognize that many obstacles to cost effective operations still remain, we feel the United States can rightly be proud of our growing fleet of reusable vehicles and the capability they represent.

Continuing efforts to make use of the STS even more effective are, in our opinion, fully justified, including the ongoing development of filament-wound booster cases, upper stages, and expanded ground processing and tank production facilities.

Each of these capabilities was recommended to you by the AIAA last year. We also endorse steps to control STS operational costs now being taken by NASA which do in fact promise to improve program economies. We strongly support additional development work aimed at even further reductions in launch costs, and at improving the utility of the space transportation system.

We are, however, somewhat disappointed this year that a specific commitment to maintaining an orbiter production capability has not been clearly made. We recognize that such a step is in fact expensive and that clear, analytical justification for a fifth vehicle cannot be made at this time solely on the basis of firm user commitments.

However, a fifth orbiter would not come on line before 1988 or 1989. Therefore, it is clearly premature by at least several years to base traffic projections for the late 1980's or early 1990's primarily on firm user commitments and to make investment decisions on the same basis. Therefore, we feel it is equally premature to preclude acquisition of additional orbiters in the future.

Although the AIAA has not this year performed a comprehensive assessment of the requirements for a fifth orbiter, we recognize that there are in fact several factors which appear to reduce the projected near term Shuttle traffic demand from previous AIAA assessments.

First, in the field of space science, several previously planned programs have either been rescheduled to a later time or cancelled altogether. In this category fall such missions as the International Solar Polar Mission, Galileo, the Space Telescope and the Venus Orbiting Imaging Radar.

We are also concerned by what we perceive to be a somewhat lethargic pace of development of science payloads for the Shuttle. Twenty-nine experiments by U.S. principal investigators were selected from the original announcement of opportunity in 1978.

Now, to date none of these has flown, and only three appear to have funding for future flights.

We believe, incidentally, that the problem with getting science payloads on the Shuttle is not totally due to a lack of funds, but also to the priorities within the Shuttle program. For example, it is extremely important, for the scientific users, to streamline the payload integration on the Shuttle and to reduce the overall costs of Shuttle use.

We also believe it is critical that this country make maximum use of the Space Shuttle's unique capabilities to achieve science objectives. Methods of increasing the power of the Shuttle, improving the cleanliness of the Shuttle, especially the cargo bay, and increasing the on-orbit duration of the orbiter, we believe, should be seriously considered.

Other Government programs planned for Shuttle use such as Earth observation and defense-related missions have also materialized at a somewhat slower rate than previously foreseen. Part of the problem has been the reluctance to transition low orbit civil weather satellites to the Shuttle as rapidly as directed in earlier national policies. Of course, we recognize that growing costs for the Shuttle use have made it more difficult to accelerate this transition.

Finally, for a variety of reasons, I believe, commercial demand for Shuttle launch services has not kept pace with earlier projections. One of these is simply that the Shuttle has not yet demonstrated an assured ability to provide timely launch service, though we believe that the President's recent policy directive endorsing commercialization of space activities can only be realized if the private sector is in fact convinced that adequate launch capability is available.

The STS has been designated by the President as the Nation's primary launch system for Government missions. We believe its capacity must also be sufficient to provide on-time launch of commercial spacecraft, even in light of defense priorities and potential system contingencies.

Potential commercialization of expendable launch vehicles is yet another factor which clouds this picture and makes it even harder to clearly identify the future demand for STS use. However, despite this perceived reduction in near-term launch demand, several factors lead us to believe that an investment now which retains the option for an additional orbiter or orbiters would still be wise.

We believe it is likely that per flight costs of STS operations will in fact drop as the full fleet comes on line and experience increases; that the Nation will come to rely on the STS for many of its most critical missions; that the fleet size must account for potential outages of vehicles or of the fleet itself; that scientific, commercial and other uses of the orbiter will, as I mentioned, require longer on-orbit stay times and more flexibility than currently planned; and that the overall demand for space launch services worldwide will increase over the next two decades.

These factors all point to the likely need for a larger fleet. We therefore support the strategy of timely acquisition of structural and component spares in order to keep the cost of future vehicles within our reach.

In conclusion, Mr. Chairman, let me reiterate that the United States, through persistence and ingenuity, has created a marvelous aerospace machine. With it and with this fleet we will deliver spacecraft, repair, retrieve and assemble vehicles, conduct exquisite scientific experiments, and learn a great deal about orbital operations.

It is a vehicle which can take a specific crew, trained to do a specific job, to a specific point in space at a specific time, support them in the execution of their tasks, bring them home again and be ready to repeat that feat time and time again. That is a capability unique in all the world.

Certainly, Mr. Chairman, the Shuttle has indeed opened the door to routine manned space operations. Only the future will show how to capitalize on what we are now learning. But we are in fact learning. And, with your help and that of the Congress, we will continue, I believe, to be the world's leading space-faring Nation.

Thank you, Mr. Chairman.

[The statement and material referred to follows:]

STATEMENT OF DR. MICHAEL I. YARYMOVYCH, PRESIDENT, AIAA AND DR. STANLEY G. ROSEN, CHAIRMAN, AIAA SPACE SYSTEMS TECHNICAL COMMITTEE

INTRODUCTION

The AIAA is a non-profit technical professional society with over 34,000 members who are engineers, scientists and students engaged in every sector of the aerospace profession from industry to government to the universities.

The Institute's professional membership is divided into 68 sections around the country. To further scientific and technical advancement, we have 51 technical committees covering every aspect of the aerospace profession. Our testimony today does not necessarily represent a consensus of our membership, any more than one administration is a perfect representation of the will of all the people. Our testimony represents the expertise of a select group of our members who were given this responsibility by the Institute's Vice President for Public Policy. Accompanying me here today is Dr. Stanley Rosen, Chairman of the AIAA Space Systems TC, who in consultation with other technical committees has prepared our testimony, on which I have given my approval.

We welcome the opportunity to offer an outside perspective on our nation's role in space. As we observe the 25th anniversary of the NASA, we recognize the need to build on our heritage and to maintain a balanced and dynamic civil space program within the fiscal constraints of the 1980's.

As we have consistently reported to this subcommittee in the past, the NASA program is, in our opinion, the wrong slice of the federal budget in which to trim our nation's relatively modest ongoing investment in research and development. To this end, last year we generally endorsed the level of NASA space activity proposed by the Administration, while pointing out several areas where an increased investment was justified. We commend this subcommittee, as well as the entire Congress, for appropriating more resources for NASA than were originally requested.

As President Reagan clearly recognized in his State-of-the Union Address, we live in a country ever more dependent on technology for its strength and survival. We therefore feel confident that there are few ways to better invest in the nation's future than in the civil space program, an aera which today commands an exceedingly small portion of the federal budget.

Dr. Krafft Ehricke, a noted aerospace prioneer, AIAA Fellow, and 1981 winner of the AIAA Space Systems Award, emphatically stated in the April 1982 issue of Astronautics and Aeronautics that government support for the creation of new wealth through investment in advanced technology is essential. Furthermore, he noted that "NASA happens to be our most efficient, creative, productive, cost-effective, and regrettably underused government agency—a powerful asset for national growth." We agree with this perspective, as do numerous studies over the past decade. Government support of civil space activities contributes directly to the maintenance of national vitality and security.

Mr. Chairman, we noted here last year our view that 1983 would be a watershed year for the civil space program. With the inauguration of operational shuttle activities, including TDRSS, the Inertial Upper Stage, Spacelab, and related civil, commercial, military and scientific activities, this year we are beginning a new chapter of our national space program. We are witnessing a major redirection in our nation's planetary exploration program. The strong need for government and private sector cooperation in fostering the proper development and execution of space applications has become apparent. The leadership of this Committee in promoting these and other key steps is to be commended. In Fiscal Year 1984, we must continue this trend to reinvigorate the U.S. civil space program.

Once again, the past year has also been one of intense activity for the AIAA. Through various publications, symposia, working groups and meetings, we have continued to refine our insight into current and future NASA activities. Where appropriate, I shall point out these relevant AIAA activities in commenting on specific program initiatives. However, two of our activities during the year are of especially broad significance, and I would like to mention them at this time.

First, you may recall that in 1980, the Institute conducted a side-ranging forecast for the National Academy of Sciences of Projected space technologies, missions and capabilities 2000-2020 time period. In 1982, we published the results of that review (May 1982 Astronautics and Aeronautics), and as the year closed, we were invited by the Congressional Space Caucus to update and share those results with them. In the process of preparing this upcoming presentation on potential civil space initiatives, we have crystallized an overview of the possibilities offered to our nation by civil space activities.

We also conducted, during the year, a second Institute-wide review of the Air Force's space technology development requirements and plans in cooperation with the Air Force Space Division. These reviews have broadened our perspective of our nation's potential in space. This perspective was brought into clear focus when, on May 28, AIAA issued its view of National Space Policy and, concomitantly, participated in a review and critique of the then-evolving Administration space policy. I would like to note briefly, for the record, our view of the Administration's stated policy, as compared to our recommendations last year.

Since the Administration's policy statement is classified, our remarks are limited to the unclassified release. At these hearings last year, we cited key elements which we thought that policy should contain. We recommended that the policy be prepared in the open, not subject to partisanship or expediency. To the degree allowed by security considerations, we feel this criterion was aptly met. We in the AIAA participated in working-level reviews. Moreover, we suggested that an effective space program should be based on clearly throught out and prioritized goals and programs to reach them, while pointing out the critical distinction between policy and programs: policy sets the direction and goals, programs are steps that progress in those directions. A policy of stabilization and commitment was recommended. We will comment on the adequacy of the National Space Policy in this regard in a moment.

Finally, we endorsed a reaffirmation of the policies of the Space Act of 1958 in fostering international cooperation and maintaining separation between military and civilian space endeavors. These tenets, too, have been reaffirmed.

In our May 28 Policy statement, we elaborated on these principles. As we recommended, the Administration policy did indeed establish goals for the U.S. space program, as well as a set of principles to be followed in pursuing those goals. Perhaps the most significant of these tenets, in our view, is that the United States will maintain the position of space leadership it has up to now enjoyed. In this and other basic goals and principles, the AIAA endorses the Administration's position.

Moreover, specific policies which have been established in the areas of continued commitment to an operational and cost-effective space transportation system, and to ongoing civil and national security space activities are consistent with and, in many cases, go beyond the AIAA's recommendations. Finally, the AIAA agrees with the strategy of encouraging commercialization of space-related activities, where appropriate.

We will discuss the specific implementation of these policies as they are evidenced in the fiscal year 1984 NASA program later in this statement.

There are two major areas, however, in which the Administration's position falls short of AIAA expectations. As we mentioned in last year's testimony, and formally endorsed in May, the AIAA feels it is essential that the nation now commit itself to an evolutionary program to establish and maintain a multi-purpose facility in low earth orbit. Such an orbital capability would use and complement the space shuttle's ability to enable human operations in space. We believe eventual long-term habitation is a capability the United States should pursue. The Administration's policy commitment to "permanent space facilities" is ambiguous, however, and subsequent pronouncements by the NASA leadership and this year's budget submittal leave us somewhat uncertain as to the Administration's current course.

In our opinion, a second needed policy element is a firm commitment to a specific national space program plan, complete with schedule milestones. Such a comprehensive statement of strategy has not yet appeared. Although we have taken no position as to the specifics of such a plan (other than those already mentioned), we have repeatedly emphasized the need for long-term commitments to add needed stability to our efforts. As I noted here last year, stability, itself, will go far toward insuring the vitality of U.S. accomplishments in space.

Mr. Chairman, we are prepared to offer more detailed commentary at a later date on current National Space Policy should such a critique be requested.

To summarize the implications of these introductory comments, we believe the National Aeronautics and Space Administration should:

Make a firm commitment to a national space program plan, in its area of responsibility.

Continue scientific exploration of the Moon, comets, asteroids, the planets, the Earth, the Sun, the stars and the Universe.

Continue and intensify development and, when possible, promote commercialization of communications, earth-observation, space materials, processing and manufacturing capabilities.

Continue and initiate vigorous programs in the enabling technologies which are essential to all space activities.

Continue and expand the evolutionary development and effective operation of a space transportation system.

Establish a program commitment to an evolutionary manned space capability in low earth orbit.

Therefore, we will now review the proposed program in light of the commitments in stated National Space Policy, and our reaction to this guidance.

We have organized our remarks today into the areas of space science and applications, space research and technology, and space flight, which includes space transportation. We are pleased to see that, in each of these areas, the proposed program is consistent with stated policy.

However, we are concerned this year, more than before, that the proposed budget falls far short of meeting the overall objective to which we have concurred: maintenance of leadership in space activities. In light of these considerations we feel it not unreasonable, in fact it is mandatory, that we advocate today a more vigorous civil space program than that which has been proposed by the Administration.

One year ago, NASA's space science program—particularly the planetary exploration program—was severely threatened. Your Committee and the Congress responded, showing your commitment to maintaining U.S. leadership in space exploration. We commend your support and your restoration of vital funds to the planetary research and data analysis programs.

The space science budget proposed by NASA for fiscal year 1984 has made progress in addressing the concerns expressed last year. However, the Space Sciences and Applications budget remains approximately constant in real terms. We remind you that this relative equilibrium is contrary to earlier NASA assurances that once the space shuttle became operational, space science programs would be restored to former funding levels.

In the Physics and Astronomy program, the Space Telescope should overcome near-term problems and promises to open an new era in astronomy which will assure U.S. leadership in this field. Astronomers in many disciplines eagerly await its deployment. Moreover, funding for full-scale development of the Gamma Ray Observatory will broaden our knowledge of the universe at the most energetic end of the electro-magnetic spectrum. These are programs we fully support.

The Space Telescope is the first of a new generation of "permanent space facilities" which will help insure long-term continuity for space-based science. With such a program, as with the Spacelab, program stability and continuity rests more with the development of improved instruments than with vastly more expensive programs to build successive spacecraft. We therefore encourage continuing and accelerated development of advanced instrumentation for these facilities.

Retrieval and repair in orbit of the Solar Maximum Mission Satellite will be a significant step toward permanency. We are pleased to see planning for this mission progressing, as we advocated here last year.

We are concerned however by the somewhat lethargic pace of science payload development for shuttle. Twenty-nine experiments by U.S principal investigators were selected from the original announcement of opportunity in 1978. None of these has flown. Three ultraviolet experiments have hardware development money for flight in 1985-86. The 12 percent increase for shuttle payloads in fiscal year 1984 under Physics and Astronomy will now allow three X-ray instruments to be developed for OSS-2. But what of the rest? How can a principal investigator hold his/her team together for years waiting to be funded?

We believe, incidentally, that the problem is not totally due to a lack of funds, but also to the priorities within the shuttle program. For example, it is important to streamline payload integration on the shuttle pallets and reduce the overhead costs.

We also believe it critical that this country make maximum use of the space shuttle's unique capabilities to achieve science objectives. Ways to increase the power, cleanliness and duration of the orbiter should be seriously considered. I will return later to this point.

We are also pleased to see the Explorer program budget increased 40 percent. the Explorer satellite series has been one of the most productive and cost-effective programs in NASA's history, beginning with the discovery of the Earth's radiation belts on Explorer I. The new budget allows the Cosmic Background Explorer to proceed and initiates development of the Extreme Ultra/violet Explorer after several years of waiting. Augmenting the Explorer program was one of the recommendations of the Field Report on Priorities for Astronomy and Astrophysics in the 1980's, and we are happy to see that NASA is responding to their recommendation.

Turning to the area of planetary exploration, the Galileo mission to Jupiter will be an exciting voyage of discovery—the keystone of planetary exploration in the 1980's. It is vital that this program, as well as the Centaur development, stay on schedule to maintain vitality in our planetary exploration capability.

We are particularly gratified by the Venus Radar Mapper new start proposed for 1984. This program, the first planetary new start in seven years, will produce a complete map of the surface features of Earth's sister planet using radar to penetrate the thick cloud cover which prevents optical instruments from viewing the surface. We can expect a better understanding of the geological history of all the terrestrial planets to emerge from this mission including important new insights into our Earth's geology. VRM will complement the wealth of atmospheric data from Pioneer Venus and contribute to U.S. leadership in the exploration of the terrestrial planets.

Most other elements of the space science budget, including the single spacecraft International Solar Polar Mission and Life Sciences, are receiving adequate support.

However, in one very important area the Administration's budget has not reflected last year's debate. We refer to the Research and Analysis line item in the Planetary Exploration budget which has received a 10-percent cut in fiscal year 1984. If left unchanged, this would translate into a loss of 150 of the approximately 600 research programs now funded, or 1 out of 4 planetary scientists. Alternatively, crucial facilities would be closed down. (The $5 million increase in the Mission Operations and Data Analysis line item is earmarked for mission operations, particularly preparation for Voyager's encounter with Uranus. In fact, much of the Voyager saturn data still waits to be interpreted for lack of research funds.)

In fact the research and analysis budget in a number of space science disciplines have been eroded over the last several years. Not only are young scientists being discouraged from entering these fields, but established research teams, their experience gained from a decade of space experiments, are being disbanded. We consider this a tragic loss of our nation's investment.

There is frequently an arbitrary distinction drawn between "basic research" and "missions" in NASA budget and planning discussions. Research aimed at understanding the solar system, the universe, and our place in it is a continuum composed of theoretical and experimental work in geo-space, and atmospheric planetary science. From the scientific point of view, missions are merely the largest and usually most complicated and expensive experiments. As with modern particle physics, such experiments tend to run for long times and require the talents of large teams of scientists and engineers. It is all too easy to assume that our country's space science needs are satisfied, once a few major missions are underway, even if other research budgets are being cut. However, to realize the benefits from space missions and prepare in a reasonable way for future missions, it is necessary to have a vigorous and complete research community working in the fields of planetary and space science. This community cannot be supported by mission budgets alone, and this fact, combined with the need for an underlying base of scientific research, forms the justification for a continuing "critical mass" of NASA-supported research and data analysis programs. Without a vital space research community to generate new ideas, the full value of data from even the most spectacular mission would never be realized.

You have continued to recognize the value of basic research support. We believe it is consistent with your previous position to restore specifically the few million dollars to planetary research and analysis necessary to maintain a minimum viable program and to continue the upward trend established in fiscal year 1983 in other areas of space science.

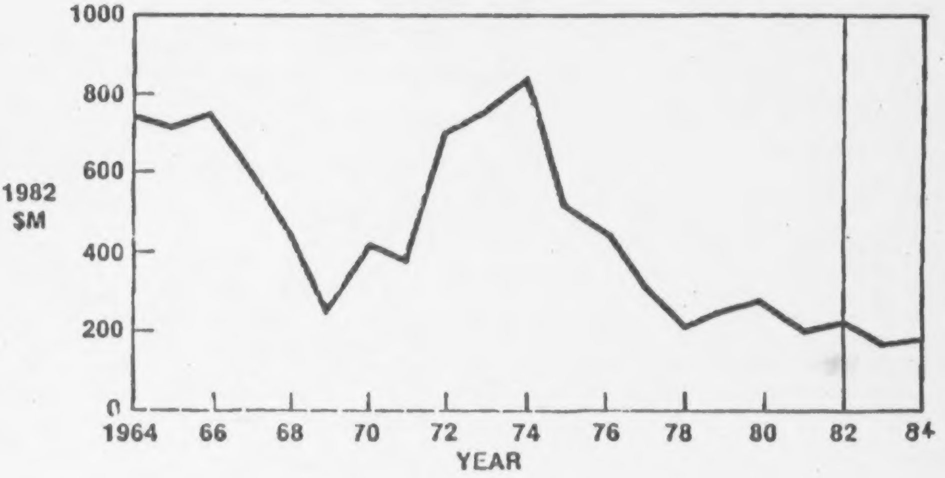
There is no dobut that our planetary exploration program, from the original Mariner 2, 20 years ago, to the spectacular Voyager flybys of Jupiter and Saturn, has been a visible symbol to the world of America's technological leadership. But the retrenchment of the U.S. planetary program in the past several years—the lack of new starts, the cancellation of NASA's solar Polar spacecraft, the failure to develop a mission to Comet Halley—is viewed by the world as a signal that the United States is losing its technological leadership, losing its will to compete. At a recent international scientific conference, there were frequent jokes about the "tortoise and the hare," as the Soviet Union prepares two major space missions to Venus and Comet Halley in 1985-86 and successfully solicits Western European cooperation.

NASA's 1984 budget has made a good beginning in reversing that trend. However, the funding for planetary exploration remains at approximately 25 percent of the level a decade ago, as the accompanying chart illustrates. NASA's Solar System Exploration Committee has recommended a core program for planetary exploration. The first four elements of the core program are the Venus Radar Mapper, a comet rendezvous/asteriod flyby, a Mars geochemical/climatology orbiter and a Titan probe. The American Institute of Aeronautics and Astronautics endorses the SSEC Core program and recommends that NASA proceed as quickly as possible to implement the four missions listed above.

We hope that a reinvigorated planetary program, as discussed in the October 1982 issue of A/A, together with continued advances in space science, will demonstrate U.S. determination to maintain a competence in science and technology vital to our economic prosperity and national security. In that light, we commend the efforts of the Astronomy Survey Committee, who carried on a tradition of two predecessor committees under a charter from the National Academy of Sciences, and established a clearly defined program for advancement in astronomy and astrophysics research spanning the next decade. We suggest that the National Academy of Science should be encouraged to provide similar leadership in the formation of a survey committee to formulate a prioritized set of program objectives spanning a similar period of time and encompassing all disciplines of Space Science. A parallel effort by the National Academy of Engineering in space applications is also appropriate. We expect that Congress could then justifiably support such programs and provide NASA the means of implementation.

In summarizing our views of space science, we believe that the program is no longer on the critical list. Its condition remains guarded, however, pending addition of funds for planetary research and analysis. A vigorous infusion of additional dollars in the next 1-4 years will be needed before restoration to robust health.

PLANETARY PROGRAM FUNDING
1964-1984



In the area of Space and Terrestrial Applications, we continue to support the strategy of transferring mature capabilities to other civil or commercial operators and users. Budget tailoffs for Landsat-4, and AgRISTARS reflect this trend. As we noted in our response to the Department of Commerce's request for information regarding commercialization of remote sensing systems, however, we believe it is essential that the government, and specifically the NASA, continue to lead the development of advanced remote sensing instruments. Such development efforts, which we recommended here last year, are now underway.

Also consistent with our previous recommendations, instrument development for the Upper Atmosphere Research Satellite is now at an adequate level. However, we now find ourselves in a position of potentially having valuable instruments on hand with no means to use them. We are unaware of funding in the fiscal year 1984 budget for development of either a free-flying spacecraft or Spacelab hardware to support use of UARS instrumentation on a timely basis. This programmatic shortfall should be corrected.

Other programs aimed at achieving a more complete understanding of the interactions between near-earth space and terrestrial environment also have our full support. A detailed article in the July/August 1982 issue of Astronautics and Aeronautics highlighted the significance of these efforts.

The increase in space materials processing research in fiscal year 1983 was especially encouraging. As we noted in the past, the potential for commercial application of materials produced in space is now being examined. We cannot and should not allow valuable processes, based on the unique capability of the space shuttle to return material from space, to go undiscovered. Nor should we forfeit this area to potential foreign competitors. Continued support for this area is well justified. We commend NASA's innovative approaches to encouraging industrial participation in space materials processing.

Additions made to the communications budget in fiscal year 1983 for development and demonstration of advanced space communications technology are especially noteworthy. The currently proposed course of developing and flying Ka-band (30/20 GHz) components and systems in an Advanced Communications Technology Satellite (ACTS) has our endorsement. This course should be followed using the most cost-effective method possible. However, we strongly believe that the United States must continue to develop this technology now with or without commercial participation, to maintain leadership in this critical area.

I want to reiterate at this point our view that the Administration's goal of moving applications programs to the private sector is sound. The immediate task is to identify and help resolve obstacles to effective and timely transition, while maintaining adequate technical support in the interim. Improperly planned actions here can have a significant adverse effect on our nation's economic, political, and military strength in the next decade. It therefore seems difficult to understand why an Administration dedicated to private-sector business development would once again propose to cut back funds for technology utilization. The AIAA's experience in our special programs involving many of the Fortune-500 non-aerospace corporations, described in the June 1982 issue of Astronautics and Aeronautics, has clearly demonstrated the usefulness of these relatively small efforts in bringing NASA-developed technology and services to the non-aerospace private sector, a function which is oriented precisely in the direction this Administration has identified to rebuild the nation's economy.

AIAA's program alone has brought more than 500 non-aerospace R&D executives from over 170 "Fortune 500" companies face-to-face with NASA specialists in a wide variety of subjects. Let me cite the experience of just one company—Deere & Co., the farm machinery company—as reported by Gordon Millar, Vice President Engineering, as a direct result of the thirteen briefings AIAA and NASA have put on over the past three years.

"We at Deere have new technology needs that couldn't be met internally . . . we realize that if we're going to be competitive in the global market we have to incorporate the newest technologies. This program made us realize that NASA is the finest technological resource in the world, bar none. You simply cannot find that technological depth and scientific capability anywhere . . . We've built one-on-one relationships between Deere and NASA specialists in many technological areas over the past three years that began with this program. For instance, one of our engineers was working on a new mechanical component that required an adhesive bonded joint, a technology new to Deere but routine to NASA. With their (NASA-Langley) suggestions . . . a fatigue life improvement of tenfold was achieved. The prototype assemblies have passed their first tests."

That kind of transfer is happening in dozens of Fortune 500 companies. We want to expand this transfer—not only to the large companies but small ones.

But they won't be able to do that if the OMB decision to cut the Technology Utilization Program from $9 million to $4 million is permitted to stand.

Mr. Chairman, this is exactly the kind of technology transfer that John Kennedy was talking about when he justified the Apollo decision back in 1961. What a tragedy it would be if penny-wise pound foolishness caused this program to be decimated. Put back the $5 million! Its seed corn for future crops.

I would now like to turn to the Space Research and Technology portion of the budget. We have consistently pointed out that this is the area we consider to be the heart of NASA's and our country's future civil space capabilities. The 12-percent increase proposed here is a healthy sign for the future of the U.S. space effort. Technology base programs are up over 9 percent, and funding allocated to important space flight experiments has been increased by over $2 million over Fiscal Year 1983. We strongly endorse these trends.

Even in light of the overall increase in this area, however, examination of the specifics of the proposed Research and Technology budget indicates that funding may not be available for many needed programs. A large portion of this funding appears to be earmarked for space station-related technology development. Although we support an evolutionary approach to a space station, we urge caution in channelling significant technology funding toward such an initiative, without a clear concept of the requirements or design constraints. Such a strategy is of special concern when it is pursued at the expense of other worthwile opportunities.

This caution is especially appropriate in a budget which has only a small allocation of funds for advanced technology development in the Space Science and Applications, and Space Transportation areas.

Within these constraints, then, NASA must rely heavily on industry to advance the state-of-the-art in such critical areas as software development, system analysis, electronic devices, sensor research and the development of engineering tools. However, Congressionally mandated limits on industrial independent research and development (IR&D) will severely constrain private investments. We strongly feel that the ceilings which have been imposed on IR&D are not in the nation's best interest, and that this legislation should be reexamined.

For several years we have expressed specific concern about support for advanced liquid rocket propulsion technology. We will soon publish an Institute position paper citing specific areas of national weakness in this vital technical field. The budgetary increase in this area in Fiscal Year 1983 was heartening, but this year's leveling off of chemical propulsion research and technology funding may leave the United States in a position where it is unable to effectively produce needed advancements to capitalize on other technical opportunities or meet future requirements. As you know, many space technology advancements take years from concept inception to fruition. Perhaps none has a longer lead time or a more intense impact on system costs and capabilities than rocket propulsion. We urge continued growth in this critical field, and we are prepared to make specific technical recommendations.

To put NASA Research and Technology funding into perspective, it is useful to note that the total funding within the NASA budget for Research and Technology and advanced technology development is only about 2 percent of the total NASA request. In light of our early comments regarding the importance of federal support for research and development, the AIAA believes the United States should reexamine its priorities to determine whether our overall federal investment in advanced civil technology is adequate. Without such a comprehensive, across-the-board examination, individual budget lines can be set at arbitrarily low levels. With such perspective, we believe the NASA R&T budget would merit augmentation. Such a step would restore needed balance to the overall NASA program and would directly contribute to future national strength.

The final area in which specific comment on the proposed space budget is in order is that of Space Transportation. The Space Shuttle program, an arduous technical and managerial challenge, is maturing rapidly; OV-104 will be delivered in 1984. Many obstacles to cost-effective operation remain, but the United State can rightly be proud of this new capability.

Continuing efforts to make use of the STS even more effective are fully justified, including ongoing development of filament-wound tanks, the Centaur upper stage and expanded external tank production facilities. Each of these capabilities was recommended by the AIAA last year.

We also endorse steps to control STS operation costs, now being taken by NASA, which promise to improve program economies. We strongly support additional development work aimed at further reductions in launch costs, and at improving the utility of the space transportation system.

We are, however, disappointed that a specific commitment to maintaining an orbiter production capability has not yet been made. We recognize that such a step is expensive, and that clear analytical justification for a fifth vehicle cannot be made at this time on the basis of firm user commitments. However, since a fifth orbiter would not come on line before 1988 or 1989, it is premature, by at least several years, to expect traffic projections for the late 1980's or early 1990's to be based primarily on firm user commitments. Furthermore, the President's recent directive endorsing commercialization of space activities can only be realized if the private sector is convinced that the capacity of the STS is sufficient to provide ontime launch, given defense priorities and potential system contingencies. Consideration of potential commercialization of expendable launch vehicles is another factor which clouds the picture, and makes it even harder to clearly identify future STS traffic demands. However, as we noted last year, several factors lead us to believe that an investment which retains the option for an additional orbiter would be wise. We believe it is likely that: Per flight costs of STS operations will drop as the full fleet comes on line and experience increases; the nation will come to rely on the STS for many critical missions; fleet size must account for potential outages; scientific, commercial and other uses of the orbiter will require longer on-orbit stay times and more flexibility than currently planned; and the overall demand for space launch service will increase over the next two decades.

These factors all point to the likely need for a larger fleet. We support the strategy of acquiring spare parts in order to keep the cost of future vehicles within reach.

We have previously noted the need to preserve adequate funding for space shuttle experiments. Spacelab falls in that category, as well, and we are pleased to see continuing commitment to this important international scientific activity.

The Advanced Programs area of the Space Transportation budget continues to grow at a rate greater than that of the overall Agency, but in our opinion, is still desperately underfunded.

Whereas last year we advocated the urgent need for an advanced upper stage for the shuttle, we now observe that the Centaur-G and G-prime, along with the PAM IUS and other available configurations, should meet the needs we foresaw for the 1980s. Of course, they do not have the full set of characteristics needed for the long-envisioned Orbit Transfer Vehicle (OTV). To assure our nations ability to fully use space in our interest, we still believe a more capable vehicle will be required in the longer term. Planning for this vehicle must continue now if we are to be in a position to implement this capability when it is needed.

Such a vehicle could be especially attractive if it were based in low earth orbit. A propellant depot/OTV base could be a derivative of space platforms or space stations developed in the late 1980's and early 1990's. In our opinion, such an orbital terminal, as we noted last year, will be needed to make effective use of the space shuttle, providing power and other mission-enhancing capabilities. Eventually, such a facility could provide for extended habitation without the shuttle orbiter.

We endorsed development of such an evolutionary space platform capability in last year's testimony and in our mid-year assessment of space policy. Plans to pursue such a facility were detailed in the September 1982 issue of Astronautics and Aeronautics. We look forward to the completion of the current NASA/DOD studies of space station requirements and architectures. These studies will help identify the proper path to achieve needed capabilities. We are concerned, however, by the absence in fiscal year 1984 of funds to continue communitywide assessment of this program, especially at the systems level. Maintenance of strong government and industry participation is essential to achieving evolutionary space capabilities, both manned and unmanned. Whatever the selected course, this teamwork should be maintained by continuing contractor systems studies.

Among the other capabilities which we believe warrant further investigation are advanced STS and other launch vehicles, teleoperator/maneuvering systems and other deployment aids (especially critical in light of the deletion of shuttle OMS augmentation) and extended orbiter operations. A tethered satellite capability should also prove scientifically useful.

In short, these comments reflect our view that the advanced programs element should be significantly increased.

In addition to these specific budgetary observations, I would like to note that, within what we believe to be an already underfunded program NASA must comply with the provisions of Public Law 97-219, the "Small Business Innovation Developement Act of 1982." This law requires that 0.6 percent of the Agency's extra-mural research and development funding for fiscal year 1984 be channeled to small businesses. We understand that NASA has requested a ruling by the Comptroller General as to what items in its budget meet the definition of research and development as stated in Public Law 97–219. We support NASA's position that items such as purchase of Expendable Launch Vehicles and STS operations are not R&D.

While we understand the need for such help to small business, we must point out that this amount, which will grow percentagewise in future years, will, in fact, become comparable in size to the entire projected space research and technology budget. In light of our earlier remarks, our concern over the impact of this legislation on NASA's management flexiblity should be evident.

In summary, there are six areas in which the AIAA recommends specific additions to the proposed fiscal year 1984 Administration budget: (1) Shuttle science payload development; (2) Planetary research and analysis; (3) UARS flight support; (4) technology utilization; (5) research and technology; and (6) advanced Space Transportation Programs.

In other areas, we also feel that a more aggressive approach is both justified and necessary.

Mr. Chairman, as you can see, the AIAA believes, after thorough and careful review, that NASA is not being adequately supported by this Administration, in light of today's needs, priorities, opportunities and constraints.

Mr. Chairman, 25 years ago your predecessors created a marvelous social invention—the National Aeronautics and Space Administration. In the last quarter-century, it has impelled and inspired our society to almost unbelieveable heights of greatness. We trust this Congress will fuel the fire of the American spirit by supporting a strengthened civil space program. As we noted in our statement on Space Policy, released last May, "Nearly 500 years after Columbus opened a path to the new world, we can ensure that U.S. leadership in the exploration and utilization of space will bring maximum returns from the 'new world' of space to the nation's citizens and to all the people of the world."

That concludes may prepared remarks. We would, of course, be happy to answer questions.

SPACE POLICY—AN AIAA VIEW

(Prepared by the AIAA Public Policy Committee, May 28, 1982)

PROLOGUE

The modern world is influenced in every sense by technology. Space activities require some of the most advanced technicial innovations and offer some of the most significant benefits. They have brought us much of our present micro-electronics capability, as well as more accurate forcasting of weather and natural disasters, low-cost global communication and navigation, and the surveillance from space which is so essential to our national security. Space opens unbounded opportunities for expanding mankind's understanding and utilization of the resources of the universe, and for improving the quality of human life.

The United States' Apollo program, one of mankind's greatest technological achievements, was a true source of pride to our citizens and prestige to our nation. Because it was a civil program, open to the world through television via satellite, its impact was even greater outside this country. Its benefits were extraordinary; indeed, they ranged far beyond most expectations.

Today, more than a decade later, the benefits of the space shuttle are becoming evident. Our challenge, therefore, is to frame space policies and goals that will continue a rational and orderly program of space activities.

THEME

President Reagan said in his inaugural address, "It is time for us to realize that we are too great a nation to limit ourselves to small dreams." He thereby ennunciated the theme that our nation is embarked on "a new beginning" to revitalize its economy, strengthen its defense, improve its institutions, reassert technological leadership, and regain national self-esteem.

We believe that the continued exploration, utilization, and development of space is a necessary and integral part of that "new beginning." The AIAA therefore urges the Administration to make a firm recommitment to the principle enunciated in the National Aeronautics and Space Act of 1958, and to U.S. preeminence in space activities. These principles form the cornerstone of the policies and goals we propose herewith.

POLICIES

It is the national space policy of the United States to:

Maintain vital space operations in support of national security under all conditions.

Assure that space systems are used in the national interest, through maximizing the return on our past investments and developing promising new applications to keep the U.S. competitive with increasingly competent commercial space capabilities overseas.

Assure concerted and sustained space-program cooperation among the government, industry, and university communities, each fulfilling the role to which it is best suited.

Have the Federal government

(a) Continue to provide the primary support for space research, exploration, and the development of new and long-range technology, not only in its own laboratories but also in those of the universities and the industry.

(b) Encourage, by cooperation and appropriate incentives, entrepreneurial investment by the private section in high-risk, high-payoff applied research and development and the applications of space systems and technology to the commercial marketplace.

Support and encourage international cooperation consistent with the above-stated economic and national security requirement, particularly in space science and exploration.

Protect the right to travel and operate in space so that the benefits of space accrue to all mankind equitably and economically.

GOALS

The goals of the national space program are to:

Maintain coordinated and mutually supporting but separately administered civil and military space programs encompassing both long-term and short-term elements.

Establish a unified military space doctrine having a coherent architecture for maximum effectiveness in defense operations of the U.S. and its allies during periods of peace, crisis, or warfare, and assure enduring access to space systems by all military services and commands.

Sustain a federal program to achieve the practical utilization of Earth orbit through cooperative efforts with the private sector, including appropriate incentives and a careful balance of entrepreneurial risks and rewards.

Achieve routine access to space through continued commitment to an operational space transportation system sized to meet both current and projected needs for defense, commercial, science, and foreign users.

Reduce the cost and improve the efficiency of all space operations, particularly transportation, through the maintenance of an active and sustained program for development of advanced technology and giving attention to emerging problems such as geostationary orbit crowding and the proliferation of space debris.

Extend man's knowledge by systematic exploration of the Earth and its biosphere, the Moon, and the solar system using unmanned spacecraft and by studying the universe beyond through the use of both unmanned and man-tended Earth-orbiting astronomical observatories.

Extend man's capability to live and work in space by developing the orbital facilities and support systems necessary for uninterrupted operations in Earth orbit.

ACTIONS

Initial actions to begin the process of accomplishing these goals are:

Make a firm commitment to a specific national space program plan for the next two decades, identifying schedule milestones for (1) operation and expansion of the space transportation system, (2) national security and civil operations in Earth orbit, (3) science and exploration, and (4) development of the enabling space technologies.

Establish programs to develop and implement systems not only to improve surveillance, navigation, and military communications functions, but also to support and assure survivability of U.S. space capability and military ground capability against hostile action.

Initiate vigorous programs in the enabling technologies which are essential to all space activities, particularly in propulsion, large space structures, power generation, life-support systems, and robotics, to support extended-duration space operations.

Expand and intensify present efforts to establish specific private-sector incentives for public-service and advanced-technology satellite communication services, Earth observation systems, research in space materials processing, and operation of prototype and demonstration commercial space manufacturing facilities.

Initiate procedures to determine the optimum operational mode for the space transportation system once it has been fully developed and demonstrated. Such a mode could involve a dedicated federal, semi-federal, or private organization or a restatement of NASA's charter to include such operation. Whatever approach is selected should not erode the important research, technology, and development efforts which are fundamental to all space achievements in the future.

Continue and expand the evolutionary development of a versatile operational space transportation system adequate to support projected traffic demand, incorporating elements to improve the efficiency and reduce the cost of carrying freight and personnel not only from the Earth into orbit but also between various Earth orbits and other trajectories.

Establish a specific plan for the next two decades to include (1) a stable program for planetary exploration, (2) investigation of comets and asteroids, (3) reestablishment of lunar exploration activities, (4) continued development of space-based platforms for scientific observation of the Earth, the Sun, the stars, and the Universe, and (5) integration of scientific studies wherever possible in spacecraft or space platforms launched primarily for other purposes.

Establish a resolute evolutionary program commitment for a manned space facility in low Earth orbit to serve as (1) an operational base for shuttle orbiters and orbital transfer vehicles, (2) an orbital storage, power, and servicing depot, (3) a research laboratory, (4) a construction center, (5) an assembly station for higher Earth orbit missions and outbound deep space flights, (6) a support facility for low-orbit free-flying satellites, and (7) a staging area for the construction and servicing of both commercial and public-service multipurpose geostationary platforms.

By making a firm commitment to a comprehensive space policy and by taking consistent action to implement its goals, the United States can maintain a leading role in many of the space activities in which it has pioneered. Nearly five hundred years after Columbus opened a path to the New World, we can ensure that U.S. leadership in the exploration and utilization of space will bring maximum returns from the "new world" of space to the nation's citizens and to all the peoples of the world.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Is there a commercial market for a Fifth Space Shuttle Orbiter that is being overlooked by the U.S. Government, or from another perspective, is the U.S. Government capable of locating and exploiting the full commercial market for a Fifth Orbiter?

Answer. There are really two questions here which should be addressed separately.

The U.S. Government is probably not "overlooking" the commercial market for a fifth orbiter. However, more could be done to effectively market and capture that prospective traffic segment. To do this, there needs to be clear direction and policy established that furthers such efforts.

The OMB letter last year that stated the Shuttle should not be sized to capture and support commercial launch requirements is one problem. If this does, in fact, represent "national policy" that should be made clear. If it is not, we need to move out and more aggressively plan to capture that market.

There are a number of good arguments for the U.S. Government to support commercial space requirements. Our nation grew rapidly and strong partly due to the Government investments made in our national highways, waterways, and airways systems. Space transportation is no different and offers much national economic and social progress in the future. Furthermore, the higher the Shuttle launch rate, the lower the launch costs for all users, including the Government.

In summary, we recommend that in the near term the legitimate commercial user requirements be satisfied by the STS and in the longer term we should work to commercialize the Shuttle operations itself.

The second question of whether the U.S. Government is capable of identifying and exploiting this commercial market is more subjective. We don't believe that any Government organization is as capable as a highly motivated commercial enterprise in marketing. It boils down to basic incentives. To successfully compete, an active STS marketing organization has to be established, providing a single point of contact for payload integration, launch services contracting, financing and insurance. The system has to be made "user friendly" and should be aggressively marketed to the degree that competition is successfully met.

Question. Why have NASA's traffic demand projections for the Space Shuttle declined over time?

Answer. NASA's Shuttle traffic demand projections have declined largely due to a decline in the amount of money available for new payload programs. "Worst case" DOD space traffic planning, aggressive Ariane marketing and a lack of user confidence in Shuttle availability have also contributed.

The NASA budget, expressed in constant dollars, declined from a peak in 1965 to a low in 1978. From 1978 through 1983, it has varied from $6.5 to $6.8 billion, not exhibiting a constant increase. These budget excursions combined with some increases in the cost of the Shuttle program have not provided support for many programs that were planned.

Military planning for space has been conservative in that they have assumed payloads would need replacement sooner than has been the fact. Some military programs have been cancelled, but more often they have just been delayed for launch.

During this same period of time, commercial requirements have increased. User confidence in the availability of the STS has not been high, however. Commercial users, therefore, either planned for extended expendable launch vehicles (ELV) support or they have double-booked and triple-booked on the Shuttle, U.S. ELV and Ariane manifests. This has made firm STS traffic projections difficult but still indicates the size of the commercial market potentially available.

Question. Are any of these factors or reasons likely to change enough to increase the traffic demand for NASA's shuttle fleet?

Answer. All of the factors contributing to the traffic decline are expected to improve in the near term, increasing the STS traffic demand beyond the mid to late 1980's. This includes an improving U.S. economy, new DOD capabilities and responsibilities and rapidly growing commercial requirements and interests.

Approximately 70 to 80 percent of the projected STS demand is dependent upon U.S. Government funding. We would hope that the NASA budget will be increased in purchasing power as the economy improves. We all recognize that advanced technology is the key to continued national health and prosperity. Space efforts contribute much to the advancement of technology as well as producing materials and products that can be readily marketed. Space science merits new initiatives also. As the Shuttle budget decreases, these initiatives will become increasingly possible.

Space is becoming a key factor in many military capabilities beyond the current communications and surveillance systems. The importance of space capabilties is now emphasized by the recent national space policy which recognizes the need to increase the survivability of such space systems commensurate with their need. This implies proliferation, hardening and some degree of maneuverability. Active and passive measures will probably be adopted. This all implies additional satellites and systems that are considerably larger and heavier—too large and heavy for existing ELV launch capabilities. The growing Soviet emphasis on space, including their manned space station, nuclear powered ocean reconnaissance satellites, recent test launches of a prototype Shuttle vehicle, and a reported heavy lift launch vehicle, indicate a continued and growing Soviet commitment to space. They may well force an increase in U.S. capability.

In the commercial area, demand for space transportation continues to grow. National space policy encourages commercialization of space activities. Direct broadcast satellites have recently been licensed by the FCC. Videoconferencing and electronic mail has just started to grow. Communication satellite revenues are expected to be over $1¼ billion in size by 1983. From 1980 through 1990, this revenue is forecast to total over $20 billion. The total market for satellite manufacturing, ground systems and revenue during these 10 years is over $40 billion. Over 137 commercial U.S. communications satellites will be required to support this demand from 1987 through the year 2000. Shuttle support of this market benefits the users, the cost effectiveness of the Shuttle and the Government in increased tax revenue.

The other big segment of space commercialization is material processing. The recent tests performed by McDonnell Douglas on electophoretic processing have proved successful. Producing pharmaceuticals at 400–800 times the rate achieveable on the ground with 5 times the purity is indicated. McDonnell Douglas and Johnson & Johnson are committing many millions of dollars to developing this capability. It is only one of many potential space processing developments. The capability of the

Shuttle to deploy and return such products is key to such an initiative. Today there is almost no provision in the traffic model for any such activity.

One other category of increased traffic is space station support. The Shuttle will be required to either deploy and service a space station or alternatively it will serve as an interim space station itself, staying in orbit for extended durations. Either option drives up the need for additional orbiter vehicles.

Question. Can 24 launches per year be achieved with a 4 orbiter fleet?

Answer. Four orbiters can support 24 launches per year when operations mature, and certain improvements are made. This projection is based on a success schedule and does not provide excess capability to allow for major problems. Orbiter fleet launch capabilities are shown in Figure 4-1 relative to projected traffic.

This statement has several caveats. The number of launches per year is a function of (1) orbiter availability, (2) turnaround time, and (3) average time in orbit. A significant change in any one of these parameters could require an additional orbiter.

Orbiter availability is still a relatively unknown quantity. Orbiters could be "unavailable" for periods of time just as planes in an airline fleet. There are requirements for periodic inspection and repair of orbiters. The time required depends to a degree on the problems incurred.

The orbiter is always subject to damage due to ground handling or hard landings. We must be prepared to face that contingency. An orbiter at worst could be lost. We feel that everything possible has been done to design and build an orbiter that is nearly failure proof. But even with a projected reliability of 0.996 (compared to an ELV reliability of 0.94) we think there is some probability of losing an orbiter over the life of the program. We must allow for this.

Orbiter turnaround time has been improving almost as predicted and is coming down a 75 percent learning curve. A turnaround time of 36 days is predicted by the 30th flight. Of course, any significant design problem or modification could cause an increase. Conversely, there are product improvements which could also help drive turnaround down further.

As the Shuttle matures, there will be an increased requirement for extended duration missions. Additional time on orbit will be required for materials processing in space, satellite servicing, repair and recovery as well as for sortie missions such as the Spacelab. Therefore, the gains made in turnaround time may well be offset by increased orbit duration requirements.

FIGURE 4-1.—ORBITER FLEET REQUIREMENTS

Ground turnaround time	Number of orbiters required		
	24 flights per year	32 flights per year	40 flights per year
Best turnaround without product improvement:			
KSC—35 days	5	6	7
WTR—45 days	5	6	7
Projected turnaround with product improvement:			
KSC—25 days	4	5	6
WTR—35 days	4	5	6

Question. If the traffic demand reaches 32 Shuttle launches per year, what orbiter fleet size would be required to meet this demand?

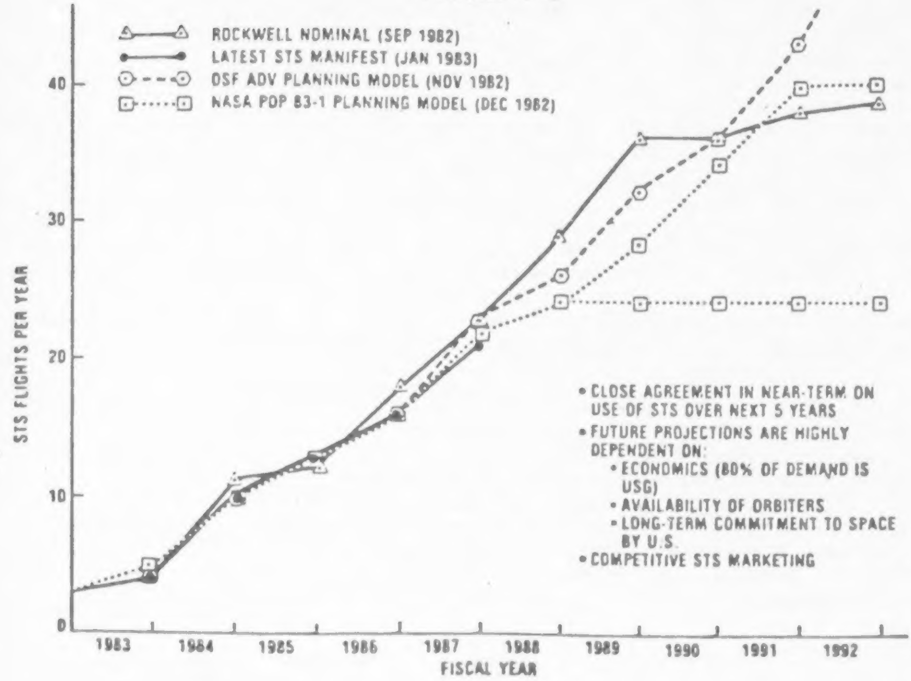
Answer. Referring again to figure 4-1, it can be seen that 5 orbiters are required to meet the demand. The same caveats apply as for the 24 per year launch discussion.

Question. What is the likelihood that the traffic demand will increase to 32 or possibly 40 Shuttle launches per year with a 4-orbiter fleet?

Answer. The likelihood that traffic demand will increase to 32 or possibly 40 Shuttle launches per year is high, assuming the Shuttle system is sized to attract and handle this launch rate. If the system is artificially limited to a four orbiter fleet, then users will be forced to seek alternative launch systems and the apparent "demand" will not grow beyond the fleet capability. Figure 4-2 shows a range of traffic estimates with good correlation. One characteristic of all these estimates is that they do not include all proposed potential missions such as new DoD capabilities, operational materials processing, space station deployment and support, or satellite servicing, repair and recovery. Some portion of these new missions will occur, driving the traffic model up further.

STS TRAFFIC MODELS COMPARISON

FIGURE 4-2



- CLOSE AGREEMENT IN NEAR-TERM ON USE OF STS OVER NEXT 5 YEARS
- FUTURE PROJECTIONS ARE HIGHLY DEPENDENT ON:
  - ECONOMICS (80% OF DEMAND IS USG)
  - AVAILABILITY OF ORBITERS
  - LONG-TERM COMMITMENT TO SPACE BY U.S.
- COMPETITIVE STS MARKETING

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In summary, the STS traffic demand could grow to 40 launches per year if we encourage such growth. We need to develop the legislation and required regulatory agencies to encourage and support commercialization of space transportation and space applications systems. If we do not support such growth, it will be accommodated by less capable commercial systems or by other nations. It can be better handled at less cost by a fully developed Shuttle system.

Question. How long can the production lines remain open so that procurement of a fifth orbiter remains economically feasible.

Answer. Orbiter production lines can be kept open for several years, retaining the capability to procure a fifth orbiter at an affordable price. This can only be done, however, if funding is adequate in these years to preclude the shut-down or unique production lines, loss of critical skills, and to support economic production rates.

If no funds were appropriated for fifth orbiter production in fiscal year 1984, most major structural subcontractors would close their production lines. For components, current funding for logistics spares retains only 50 percent of subcontractor skills through 1985. Figure 5-1 shows the impacts to any contractor forced to shut down production. Orbiter 103 is delivered in October 1983 and the fourth orbiter is delivered in December 1984, showing the urgency of capability retention.

FIGURE 5-1. *Contractor shutdown impacts*

Shutdown of tooling, machinery, and facilities;
Layoff of personnel—loss of critical skills.
Storage and maintenance of equipment and facilities.
Storage and maintenance of drawings, specifications, EO's, etc.
Termination costs of first and lower tier subcontractors and vendors.
Obsolescence through state-of-the-art advancement.
Potential loss of subcontractors and vendors.
Start-up costs.
Recertification.
Requalification.

Assuming that funds for "structural spares" as defined by NASA/OMB are provided ($100 million fiscal year 1984) an additional 30 percent of the skilled work force would be retained. This funding profile still puts the program in a going-out-of-business posture by 1986.

If the fiscal year 1984 funding is increased by $70 million, this would retain critical skills at prime and subcontractor facilities resulting in a completion cost savings of $15 million for the fifth orbiter. This increased funding allows the installation of wiring, tubing, and components at the proper time during manufacturing, reducing cost and saving five months in the schedule.

Last and perhaps not least, these funds indicate to users who are trying to decide between the Shuttle, ELV's and the Ariane, that the Government is committed to provide capacity for the future traffic growth when that becomes necessary.

Question. Ariane, the French competition in the field of launch vehicle activity has targeted 30 percent of the market for its fleet. What market-share should NASA realistically target for its 4-orbiter fleet?

Answer. NASA could realistically target about 50 percent of the available free world commercial market, assuming the Shuttle system is properly sized. If there are only four orbiters provided, users will be driven to alternative systems. If there are to be alternative systems they should include U.S. expendable launch vehicles which would compete directly with Ariane and other foreign ELV's for payloads not taken by the Shuttle.

If the Shuttle system grows to not only meet demand but attract users, this market share could grow to 70–80 percent which is equivalent to 6–8 Shuttle flights. It should be noted that up to this point Arianespace has operated in the marketplace without significant and consistent competition from the Shuttle. Making the STS user friendly is key to such competition and growth.

Question. Is a fully utilized 4-orbiter fleet more cost effective than a mixed fleet?

Answer. There have been a number of studies performed that show a fully utilized STS fleet to be more economical than a mixed fleet. Both NASA and the Air Force have come to this conclusion.

Fully utilized orbiters can be shown to be more cost effective than the required number of ELV's needed to place an equal number of payloads into orbit. The key to STS cost effectiveness is its reusability. In contrast an ELV is committed to destruction at launch. As the orbiter turnaround time decreases, permitting more flights per year per orbiter, the cost effectiveness gap grows in favor of the orbiter.

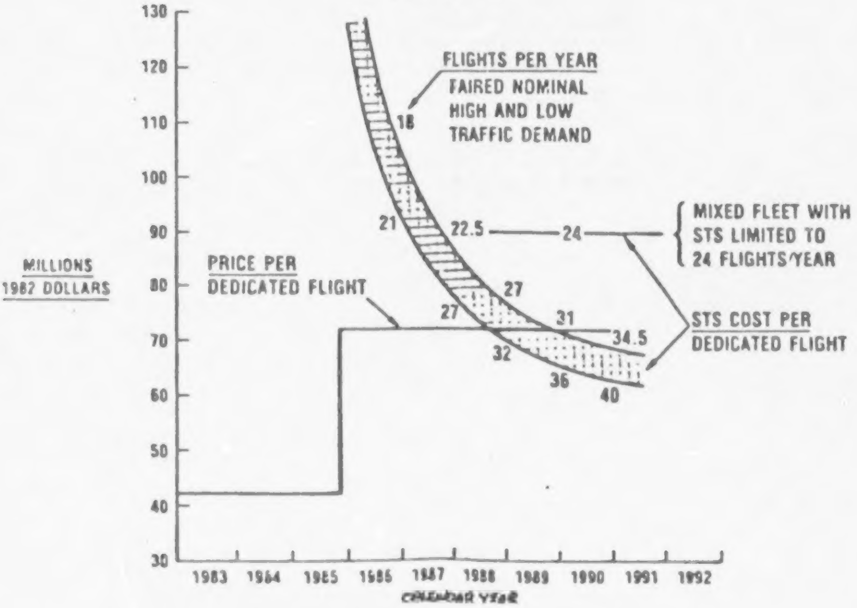
Additionally, the cost of adding another orbiter to the fleet, when amortized over its expected life of 100 flights, is minimal compared to the cost of an ELV.

This question, however, stipulates that there are only four orbiters. As long as the four orbiters can handle the traffic, a fully utilized system is more cost effective than several systems not fully utilized. With only four orbiters, there is a good possibility that some expendable launch vehicles will be required to handle the overflow. The marginal costs of these ELV launches would be more than the marginal costs of increases STS launches which drives up the total national launch costs.

Figure 9-1 shows that as STS utilization increases, the cost per launch decreases substantially below the most recently quoted price per launch. Conversely, if the system is limited to 24 launches per year, launch cost will not be reduced below the latest quoted price.

FULL STS UTILIZATION PROVIDES FOR OPERATIONS COST RECOVERY (INCLUDING VAFB) BY 1989

Figure 9-1



This question and the above discussion relate strictly to the STS as a transportation system only. It ignores all of the associated user benefits of the Shuttle, which are many and some of which can be easily quantified.

If satellites are designed to take advantage of the Shuttle's payload weight and size, many cost savings are realized. The Ford Aerospace Satellite Services Corp. is planning to launch a new generation satellite which is larger and heavier than previous satellites. The president of this company states that their pricing to users will be very competitive, and estimated 40 percent lower cost per transponder per year than with existing systems. Freedom from the constraints of the Delta expendable launch vehicle which enabled the cost efficiencies is the reason given.

The Fairchild Corp. is developing the Leasecraft for materials processing ventures. This satellite will take advantage of the Shuttle's capabilities and will periodically rendezvous with the Orbiter for maintenance and repair and to exchange finished products for raw materials. Materials processing in space could have great

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social and economic benefits to our nation and could not be accomplished with expendable launch vehicles.

A retrievable carrier called Spartan is now under development by the NASA for sounding rocket class payloads and will be deployed for the first time by the Shuttle in April 1984. This low cost program, which is designed to take maximum advantage of Shuttle capabilities increases the science return on payloads 200 times (compared to ELV launches) while only doubling the cost.

These are but a few examples of Shuttle benefits which must be considered in any discussion of Shuttle and a mixed fleet. The Shuttle launch costs should be discounted somewhat by the special benefits that accrue to the user and to the nation by the use of the Shuttle.

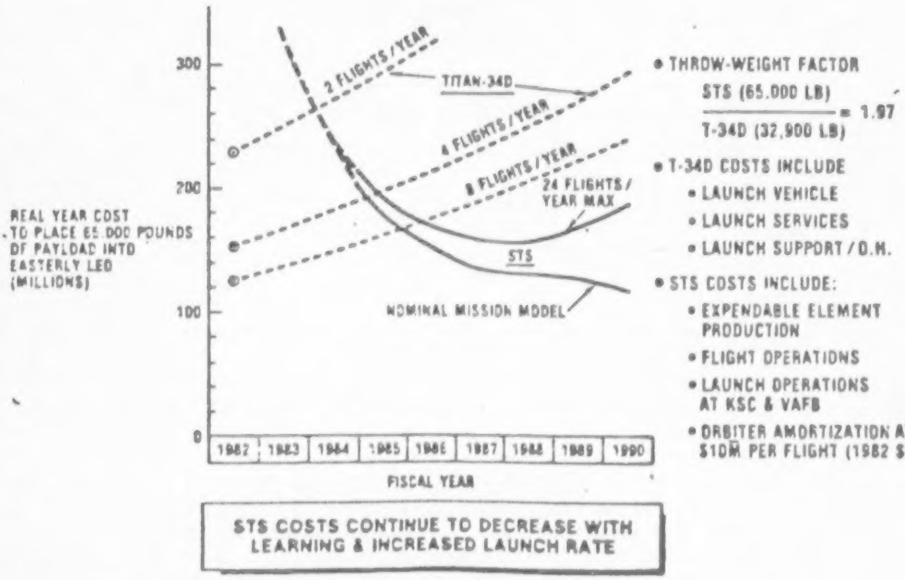
Question. What is impact of delaying fifth orbiter production in terms of reduced flight capability, higher cost per flight.

Answer. In the time period (1988) when the fifth orbiter could be required, it is projected that each orbiter will be capable of approximately 7½ flights per year. If the fifth orbiter is delayed the fleet capacity will be reduced by the amount.

The cost per flight will be increased by the amount that STS overhead costs would not be amortized by fifth orbiter operations, and the national launch costs would rise by the increased marginal costs of additional ELV launches.

Figure 10–1 shows the reduced cost per flight achieveable for the STS by increasing the flight rate beyond 24 flights per year. In 1988, the cost per launch of a fully utilized STS system is $32 million less than one constrained to 24 launches per year. The costs savings continue to be more significant as the launch rate increases. For comparison, figure 10–1 also shows that Titan launches cost more to put the equivalent payload weight into orbit.

STS PROVIDES LOWEST COST
(TO PLACE 65,000 POUNDS OF PAYLOAD IN LEO AFTER 1985 FROM KSC)



- THROW-WEIGHT FACTOR $\frac{\text{STS (65,000 LB)}}{\text{T-34D (32,900 LB)}} = 1.97$
- T-34D COSTS INCLUDE
  - LAUNCH VEHICLE
  - LAUNCH SERVICES
  - LAUNCH SUPPORT/O.M.
- STS COSTS INCLUDE:
  - EXPENDABLE ELEMENT PRODUCTION
  - FLIGHT OPERATIONS
  - LAUNCH OPERATIONS AT KSC & VAFB
  - ORBITER AMORTIZATION AT $10M PER FLIGHT (1982 $)

STS COSTS CONTINUE TO DECREASE WITH LEARNING & INCREASED LAUNCH RATE

Question. We should consider two other factors in this discussion. Turnaround time, which is the time from the orbiter landing until its next launch, will decline with time. Also, the Shuttle will increase its length of time in space per flight as we become more comfortable with the capabilities of the Shuttle and as different scien-

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tific experiments are placed aboard the Shuttle. Could you please comment on these two factors in terms of how they could affect the decision to procure a 5th orbiter?

Answer. This question has been answered almost entirely in the discussion of question number 4. We should, however, add a few more comments on turnaround time and time-on-orbit prediction.

Predicting Orbiter turnaround time is difficult. It is a function of learning, days worked per week, hours worked per day and the investments made to reduce turnaround time through improvements to the system.

Learning to date is about 75 percent, that is, each succeeding operation takes about 75 percent as long as the previous. The Shuttle turnaround assessment report (STAR) predicts a 36-day turnaround (working day) by the 30th flight. If investments were made in system improvements, turnaround time could be reduced somewhat, perhaps to 25 days.

At the same time, there are growing requirements for extended on-orbit mission times as previously discussed. A recent report from MBB/ERNO shows many Spacelab type missions that require 15–30 days on-orbit for maximum effectiveness with several missions showing from 90–180 days desired. Materials processing, space station support and prototype system demonstration will all require extended duration missions. Gains made in turnaround time could easily be offset by these extended duration missions in terms of the number of flights per year per orbiter.

Question. What are the constraints in achieving 24 shuttle flights/year—40 flights/year?

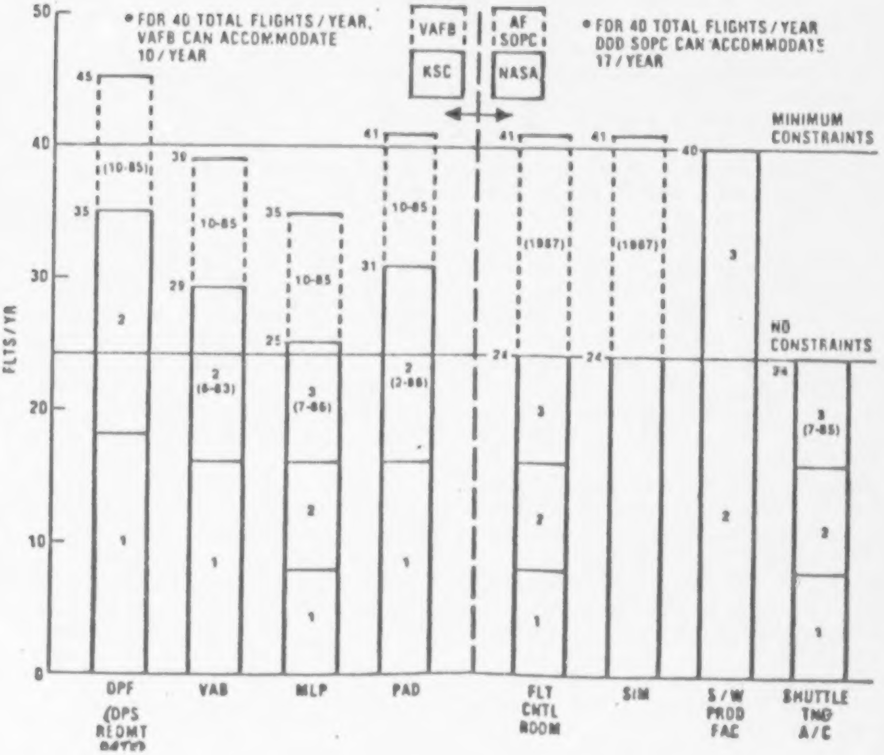
Answer. Various assessments have been made by both NASA and industry to identify constraints and the additional resources necessary to expand the Space Shuttle capability from the baseline 24 flights/year up to 40/year.

The planned facilities at KSC and JSC are all sized to accommodate at least 24 flights/yr with some facilities capable of 40 flights. In addition, the DoD is developing Vandenberg as the Western launch site to accommodate from 8 to 10 flights/yr; and will build the Shuttle Operations and Planning Center (SOPC) to support at least 17 flights/yr.

Figure 12-1 shows the combined capability of both NASA and DOD facilities, including the number of units at each facility, and the associated operational requirement dates (ORD).

LAUNCH CONSTRAINTS

12-1



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At a rate of 40 flights/year, approximately 8 of these flights will be launched from VAFB. The requirement for KSC will only be 32 flights which presents minor constraints at the Vertical Assembly Building (VAB) and suggests an additional Mobile Launch Platform (MLP) might be required. Actions currently underway to streamline the turnaround process are expected to reduce future facility needs, but the degree of reduction is uncertain.

In addition to the launch facilities shown, there is a possibility of additional processing facilities, such as ET facility and tooling at Michoud, the SRM facility at Thiokol, the payload processing facility at KSC, and the SRB processing facility at DSC. There is a small possibility of needing an additional firing room, ET storage at KSC and modifications to expand the flight control, training and software production capabilities at JSC.

Question. In terms of producing an additional orbiter for the future after the 4th or, possibly, a 5th orbiter, should we continue the design of the present generation of orbiters or should we "freeze" production of the current design and initiate the design of a new generation of orbiters?

Answer. We recommend continuing with the present orbiter including cost-effective improvements where appropriate.

The orbiters can perform all known basic requirements (deployment retrieval and servicing) in the current configuration.

With improvements in duration and military accommodations, the orbiters can perform most anticipated requirements within our planning horizon.

Traffic demand is expected to grow enough in the early 1990's that a new system could not be developed in time. During the latter 1980's studies should be done to see if a new system will give required performance and if so, development should start when costs relative to need can be effectively matched. We do not believe development should start before the 1990's at the earliest.

Senator TRIBLE. Dr. Heiss.

Dr. HEISS. Mr. Chairman, thank you very much for the opportunity to present my views on the question of the need for a fifth Space Shuttle orbiter. I am president of the Space Transportation Co. which was formed in 1979 to commercialize space transportation services. My own involvement in the Space Shuttle and related questions dates back to the late 1960's and early 1970's.

I have prepared a written statement on the question of orbiter V from a national perspective for these hearings which I ask be included in the record.

The key findings in the prepared statements include: one, the funding of orbiter V is a pivotal issue to the Shuttle and space programs. When the Nation decided in 1972 to proceed with the development of a space transportation system, a minimum of five and possibly as many as nine orbiters were considered necessary for the 1980's and 1990's.

Two, the key Space Shuttle issue identified in 1971 was the need for a strong U.S. space science and applications program to make use of the Space Shuttle in the 1980's. Such a program, parallel to the Shuttle development, was not created in the 1970's. As a result, we see today a substantial reduction in the Government demand, and possibly commercial demand as well, for Space Shuttle flights for the rest of this decade. Given this lack of Government demand, the Government need for orbiter V in the 1980's is uncertain.

Three, the delay in orbiter V procurement and the concurrent reduction of demand for space transportation have made a four-orbiter fleet economically inefficient throughout the 1980's. A freeze of the Shuttle fleet at four orbiters for the rest of this decade will make the Shuttle fleet noncompetitive in the world market through at least 1995.

Four, the operations cost per flight of a four-orbiter fleet will be at least $120 million in 1983 dollars averaged over a 12-year period and may be even higher. An increase of the Shuttle user charge from $71 million in 1986 to 1988 to $120 million, the 12-year average operations cost per flight, will leave most of the commercial space transportation market to foreign ELV's, expendable launch vehicles.

Five, an additive cost, out-of-pocket incremental marginal cost pricing policy will have to be applied through at least the 1980's if the United States is not to lose world space transportation markets to foreign competition.

In the 1986–88 period, even out-of-pocket costs for the Space Shuttle will have to be partly subsidized by the Government to meet the projected $71 million user charger for Space Shuttle flights.

Six, a substantial commercial and world market exists for space transportation services estimated by SpaceTran at between $10 billion to $15 billion from 1983 to 1995. Without an economically efficient U.S. space transportation system, this market will increasingly be serviced by foreign launch systems.

The SpaceTran assessment of the potential commercial demand for the Space Shuttle is summarized in table 4.1 and figure 4.1 of the prepared statement. SpaceTran projects a total of 183 commercial payloads from 1985 to 1995 for the Space Shuttle. These projections assume competitive Space Shuttle operations, costs and user charges.

A more uncertain but exciting part is the demand for Shuttle-unique capabilities by the commercial sector. The most immediate of these, material processing in space, may range from a low of 42 payloads up to 234 payloads through the end of this century.

Seven, given the commercial and worldwide space transportation market and with the establishment of a reliable, fully operational Government fleet of four orbiters over the next few years, the private sector can afford to fund one or more orbiters in the 1980's and 1990's. If orbiter V were funded by the private sector, the terms and conditions will have to be on an additive cost basis for orbiter vehicle costs and the cost-per-flight reimbursement to the Government operator of the Space Shuttle fleet throughout the life of orbiter V.

Eight, in the near term, the commercialization of U.S. expendable launch vehicles such as Titan will allow the United States to capture a significantly larger share of the world's space transportation market. At the same time, such commercialization will discourage and delay the full development of foreign competition.

Nine, no new Government funding is required to bring about the commercialization of U.S. ELV's. Let the market determine which system finds what role in worldwide competition. However, Government decisions are needed right now to give the U.S. ELV's a chance to compete efficiently in world markets.

Fundamental to the question of the need for orbiter V is an affirmation of U.S. Government and industry cooperation to realize the full potential for U.S. space enterprise in the next two decades. The retrenchment of the U.S. space program in the 1970's leading to the questions and issues of today needs to be reversed by a forward-looking Government space program, including a new space goal that will make use of the technical capabilities created by the Space Shuttle.

For the U.S. to advance and capture its part in the space enterprise in the 1990's, Government initiatives and private sector initiatives have to go forward jointly. The private sector can make its contribution with full Government cooperation and efficient rules for the transition to more expanded commercial private sector intitiatives, including space transportation.

The U.S. aerospace industry has been the most dynamic and innovative sector of U.S. industry in world markets and is the largest contributor to net trade, exports minus imports. For every dollar of sales, U.S. aerospace industry makes a net trade contribution of more than 20 cents, and for every dollar of sales, aerospace spends 20 cents on research, development, and testing.

The aerospace industry has been for some time an example of successful Government-industry cooperation. Let us continue this example in space matters. The economic stakes for the United States are enormous. Too much time has already passed. This is not a zero-sum situation where whatever the commercial sector gains the Government necessarily loses. Rather, like most economic issues, space in particular is a positive-sum opportunity. If pursued jointly and fully, the U.S. share in world space markets of the 1990's will be large indeed.

Without such new direction, we may well repeat the mistakes of the 1970's while other nations will catch up and overtake where the United States has led for so long.

In the context of the new forward-looking space program, centered around a new civil space goal and an active policy of encouraging commercial enterprise in space transportation and space applications, the need for additional orbiters, including orbiter V, will become obvious. And the private sector is willing to do its share to bring about such funding.

Mr. Chairman, thank you very much for the opportunity to give my views on this important question.

[The statement follows:]

Statement of Dr. Klaus P. Heiss, President and Chief Executive Officer, Space Transportation Co. Inc. (Spacetran)

Mr. Chairman, thank you very much for the opportunity to present my views on the question of the need for a fifth space shuttle orbiter. My own involvement in this and related questions dates back to the late 1960's and early 1970's. The key findings in the prepared statement include:

(1) The funding of Orbiter V is a pivotal issue to the shuttle and space program. When the nation decided—in 1972—to proceed with the development of a new Space Transportation System, a minimum of five and possibly as many as nine orbiters were considered necessary for the 1980's and 1990's.

(2) The key space shuttle issue identified in 1971 was the need for a strong U.S. space science and applications program to make use of the space shuttle in the 1980's. Such a program—parallel to the shuttle development—was not created in the 1970's. As a result, we see today a substantial reduction in the government demand—and possibly commercial demand as well—for space shuttle flights for the rest of this decade. Given this lack of government demand, the government need for Orbiter V in the 1980's is uncertain.

(3) The delay in Orbiter V procurement and the concurrent reduction of the demand for space transportation have made a four-orbiter fleet economically inefficient throughout the 1980's: A "freeze" of the shuttle fleet at four orbiters for the rest of this decade will make the shuttle fleet non-competitive through at least 1995.

(4) The operations cost per flight of a four-orbiter fleet will be at least $120 million (1983 dollars) averaged over a 12-year period—and may be even higher. An increase of the shuttle user charge from $71 million (1986–1988) to $120 million (12-year average operations cost per flight) will leave most of the commercial space transportation market to foreign ELV's.

(5) An additive cost ("out-of-pocket", incremental, marginal cost) pricing policy will have to be applied throughout at least the 1980's, if the United States is not to lose world space transportation markets to foreign competition. In the 1986–1988 period, even "out-of-pocket" costs for the space shuttle will have to be partly subsidized by government to meet the projected $71 million user charge for space shuttle flights.

(6) A substantial commercial and world market exists for space transportation services, estimated by SpaceTran at between $10 billion to $15 billion from 1983 to 1995. Without an economically efficient U.S. space transportation system, this market will increasingly be serviced by foreign launch systems.

The SpaceTran assessment of the potential commercial demand for the space shuttle is summarized in Table 4.1 and Figure 4.1 of the prepared statement. SpaceTran projects a total of 183 commercial payloads from 1985 to 1995 for the space shuttle. These projections assume competitive space shuttle operations costs and user charges.

A more uncertain and exciting part is the demand for shuttle unique capabilities by the commercial sector. The most immediate of these—material processing in space—may range from a low of 42 payloads up to 234 payloads through the end of the century.

(7) Given the commercial and worldwide space transportation market, and with the establishment of a reliable, fully operational government fleet of four orbiters over the next few years, the private sector can afford to fund one or more orbiters in the 1980's and 1990's. If Orbiter V were funded by the private sector, the terms and conditions will have to be on an additive cost basis for orbiter vehicle costs and the cost per flight reimbursement to the (government) operator of the space shuttle fleet throughout the life of Orbiter V.

(8) In the near term, the commercialization of U.S. expendable launch vehicles (ELV)—such as the Titans—will allow the United States to capture a significantly larger share of the world space transportation market. At the same time such commercialization will discourage and delay the full development of foreign competition.

(9) No new government funding is required to bring about the commercialization of U.S. ELV's. Let the market determine which system finds what role in worlwide competition. However, government decisions are needed right now to give U.S. ELV's a chance to compete efficiently in world markets.

Fundamental to the question of the need for Orbiter V is an affirmation of government and industry cooperation to realize the full potential for U.S. space enterprise in the next two decades.

The retrenchment of the U.S. space program in the 1970's—leading to the questions and issues of today—needs to be reversed by a forward looking government space program—including a new space goal—that will make use of the technical capabilities created by the space shuttle. For the United States to advance and capture its part in space enterprise in the 1990's, government initiatives and private sector initiatives have to go forward jointly. The private sector can make its contribution with full government cooperation and efficient rules for the transition to more expanded commercial, private sector initiatives—including space transportation.

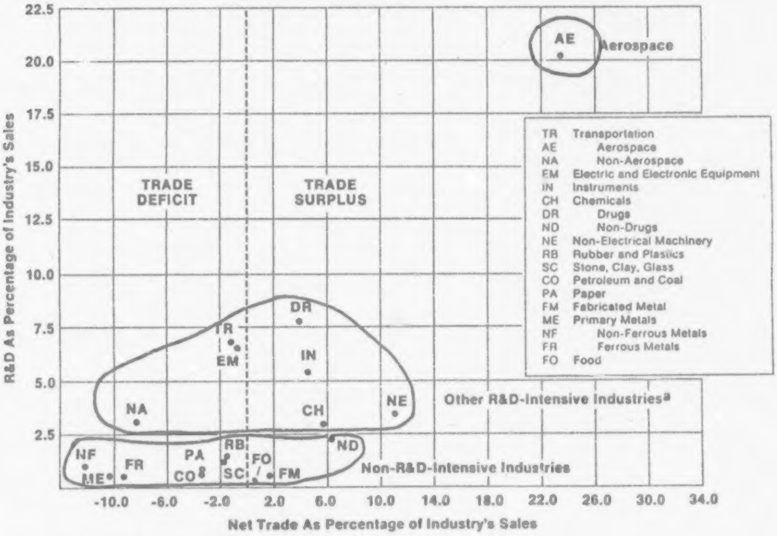
The U.S. aerospace industry has been the most dynamic and innovative sector of U.S. industry in world markets, and is the largest contributor to net trade (exports minus imports): for every dollar of sales, the aerospace industry makes a net trade contribution of more than 20 cents; and for every dollar of sales, aerospace spends 20 cents on research, development and testing (see Figure 6.1 of prepared statement).

The aerospace industry has been for some time an example of successful government and industry cooperation. Let us continue this example in space matters: the economic stakes for the United States are enormous. Too much time has already past. This is not a "zero sum" situation, where whatever the commercial sector gains the government necessarily losses. Rather, like most economic issues, space in particular is a "positive sum" opportunity: if pursued jointly and fully, the United States share in world space markets of the 1990's will be large indeed. Without such new direction we may well repeat the mistakes of the seventies, while other nations will catch up and overtake where the United States has led for so long.

In the context of such a new, forward looking space program—centered around a new civil space goal, and an active policy of encouraging commercial enterprise in space transportation and space applications—the need for additional orbiters—including Orbiter V—will become obvious, and the private sector is willing to do its share to bring such funding about.

Figure 6

R&D EFFORT AND TRADE PERFORMANCE OF MAJOR U.S. INDUSTRIES
1978



a Industries that perform R&D in excess of 2.5 percent of sales.

Source: (4, p. 22)

1.0 EVOLUTION OF THE SHUTTLE PROGRAM

The basic idea of a reusable space plane as a technically feasible step in space transportation goes back to 1945. At that time, Wernher von Braun recommended to the U.S. Government the development of such a capability. The 1950's saw a preemption of the United States by the U.S.S.R. in space accomplishments, which led to the formation of NASA in 1958 and the Apollo program of the 1960's. The space shuttle program is the result of an intense effort to define the goals of the U.S. Space Program in the late 1960's, for the "Post-Apollo" period.

The options considered then were (1) a large manned space station (MOL), (2) a space shuttle to support such a space station, and (3) a commitment by the United States to "land man on Mars" by 1981.

In 1969 the Space Task Force had settled on a commitment to land man on Mars by 1981: but the program did not achieve an administration go-ahead [1, pp. 144-145]. The manned space station (MOL) underwent a thorough study effort by the Department of Defense which led to the conclusion that a commitment of a permanent presence of man in low-earth orbit for reasons of national security was not warranted.

Obviously the establishment of man's presence in space—ultimately independent of Earth—must be considered as the single most important challenge for this nation and mankind. However, how to establish such presence remains unanswered today.

This left NASA with the Space Shuttle Program as the only component of a continued further commitment of the United States to space in the 1970's. At the insistence of the Office of Management and Budget, a detailed economic study effort on the Space Shuttle System was undertaken by NASA. I had the task of heading up that study effort which also included the Aerospace Corporation and Lockheed (LMSC).

2.0 THE 1972 SPACE SHUTTLE DECISION

The principal conclusion of that study effort was that a reusable Space Transportation System was warranted by the United States, not so much because of space transportation cost savings but because of the "payload effects," i.e., the reduction of total mission costs over a 12-year application program (DOD, NASA, other USG agencies, and commercial users), including new missions—materials processing among them—that the space shuttle made possible. "Payload effects" included the ability of payloads to make use of a larger volume and mass, payload standardization, in-orbit checkout, revisit and refurbishment of payloads.

The reusable Space Transportation System ("STS") was developed as a means to increase the access of all users to space by reducing the total cost of space operations—transportation and payload costs. U.S. Government funding was justified by the STS ability to meet U.S. Government needs in space, including: a manned U.S. presence in space, U.S. national security objectives, reasons of national prestige and various U.S. Government applications programs in the civil sector (whether, remote sensing, space research, space processing including possibly large platforms).

To understand the seriousness of the Orbiter V question today, it is important to go back and look at the economic rationale used in the space shuttle decision in 1971 and early 1972. In many ways, today's issues are also the issues of 1971. Several statements made to NASA and Congress at that time can be restated today with equal relevance.

2.1 SHUTTLE ADVANTAGE: USES OF SPACE (PAYLOADS)—NOT TRANSPORTATION COSTS

The key economic rationale for the shuttle decision in 1971-72 was not expected savings in transportation costs, but in payload and mission costs, i.e., the uses and new uses of space. The 1971 findings are summarized in the following table:

SPACE TRANSPORTATION SYSTEM COST SUMMARY—MODIFIED [REDUCED] NASA AND DOD BASELINE (1979-90)

[Millions of 1970 dollars]

	New expendable (Titan) system	Space Shuttle system
Expected total launch costs	$11,000	$12,000
Expected payload costs:		
RDT&E (1975-90)	10,000	9,880

SPACE TRANSPORTATION SYSTEM COST SUMMARY—MODIFIED [REDUCED] NASA AND DOD BASELINE (1979–90)—Continued

[Millions of 1970 dollars]

	New expendable (Titan) system	Space Shuttle system
Recurring costs (1976–90)	18,400	12,700
Expected total space program cost	~40,000	~35,000

2.2 SPACE SHUTTLE SYSTEM COSTS

The nonrecurring costs of the Space Shuttle System were anticipated to be $7.5 billion (1970 dollars) with a cost uncertainty of about $1 billion, including $1 billion for an orbit transfer vehicle (Space Tug). Translated into today's dollars, these estimates are about $22.5 billion with a cost uncertainty of about $3 billion.

2.3 SPACE SHUTTLE FLEET SIZE

A minimum fleet of five orbiters, and possibly as many as in orbiters, was anticipated for the 1980's and 1990's. Reasons for a minimum of five orbiters included—among others—attrition, turnaround time, maintenance requirements and technology evolution.

2.4 "BREAK EVEN" USES FOR SPACE SHUTTLE

The projected demand for the space shuttle was identified as the critical economic issue for the space shuttle. Whereas mission models given to us by NASA and DOD contemplated anywhere from 514 to 628 flights, about 40 to 50 flights per year, over a 12-year period, the economic analysis severely reduced both NASA and DOD projections. The breakeven level of shuttle flights per year—below which the space shuttle was uneconomic and inefficient—was determined to be between 25 to 30 flights a year.

2.5 AN EVOLUTIONARY SPACE SHUTTLE TECHNOLOGY

A prime consideration in the economic study recommendation (October 1971 and January 1972) for the shuttle configuration then chosen by NASA (the Thrust Assisted Orbiter Shuttle [TAOS] in preference over a fully reusable shuttle) was the possibility to evolve the shuttle technology base gradually forward to a more efficient, reusable, lower cost system by the 1990's. To quote [3, p. 33]: "The TAOS avoids the immmediate need to decide on a large reusable booster . . . without blocking a later transition to a fully reusable system;" "The TAOS would use 'parallel burn' concepts which . . . may change the reusable booster decision"; and "Technological progress may make the expendable parts of the TAOS system (involving mainly tank costs, and thrust assisted rocket costs) less expensive." This evolutionary approach clearly envisioned a continuity in orbiter production and improvements.

2.6 THE DEMAND FOR SPACE SHUTTLE USES

Several important considerations and issues were raised by us in 1971 concurrent with the space shuttle recommendations. The most important among these was the demand for Space Transportation. To quote, "The key question raised . . . is: Does there exist a precise and detailed NASA and national space program for the 1980's? We did receive detailed mission models of OSSA, OMSF, the DOD, non NASA applications and others. Yet these continue(d) to change substantially" [2, pp. 6–7]. Indeed, we looked at leterally hundreds of diffferent space program levels, reducing the 40 to 60 flights a year flight levels down to 25 to 35 flights.

For, as was stated then [2, pp. 11–15]:

"The most important problem remains of what the demand for space transportation will be in the 1990's."

"It is our strong belief that the major portion of space transportation demand in the 1980's will come from econommic applications of space technology to meet the increasing needs of the U.S. and other developed and developing countries."

"The point is sometimes made by NASA that the technological possibility of a space shuttle program suffices by itself to justify its construction independent of the economic analysis."

"In the present mood and the present state of the economy a program like the shuttle and its decision has to be user oriented, not in terms of who will build the shuttle and benefit by these expenditures, but rather in terms of who is going to use the space shuttle system and why the different agencies, corporations and foreign countries will do so. NASA ought to adjust to such a reorientation of emphasis."

Among the potential unique uses of the space shuttle stated then was:

"Among these are the use of space based production processes which for safety considerations, gravity, environment or other technical reasons are either too expensive or not possible when earth based."

And finally:

"Technological possibilities alone carry no conviction, though they often bring new possible aims into sight and reach. Whatever their nature and origin, the different aims must be hierarchically ordered and must find their place in the system of national priorities."

Many of these same questions and issues apply today, 12 years later.

3.0 KEY DEVELOPMENTS SINCE 1972

The key developments pertaining to the Orbiter V question today—many adverse—since 1972 may be summarized as follows:

3.1 POSTPONEMENT OF A SPACE TUG DECISION

A key component of the space shuttle system was and is an advanced (reusable) Orbit Transfer Vehicle (Tug). Whereas the European offer to develop a Space Tug was turned down by the United States in the early 1970's—leading to the Space Lab and Ariane decision by Europe—we still have no commitment to an advanced—reusable—Orbit Transfer Vehicle. The bits and pieces of upper stage programs of the 1970's and 1980's cannot be called exactly models of efficient space programming and procurement. After substantial expenditure of public funds, the nation still has no such upper stage.

3.2 STRETCHOUT OF THE SHUTTLE DEVELOPMENT

The initial operating capability of the space shuttle was originally planned for 1979. The first flight of the shuttle came 2 years later. Instead of a 40 to 50 annual flight level in the 1980's, the current plans call for a buildup to 23 annual flights by 1989.

3.3 ELIMINATION OF ORBITER V IN 1977/78

A flaw in the system's efficiency and economics was introduced in late 1977/early 1978 when the fifth orbiter was eliminated from the procurement plans of NASA. As you may recall, several drastic options were then considered, among them (1) cancellation of the shuttle program, (2) three orbiters and one launch site, and (3) the "compromise" of two launch sites and four orbiters.

3.4 REDUCTION OF GOVERNMENT DEMAND FOR SPACE TRANSPORTATION—ABSENCE OF A CIVIL SPACE GOAL

The most adverse development since 1971 was the failure to develop civil and military uses of space to put the space shuttle to work in the 1980's. Clearly, the decision to develop the space shuttle warranted an equally forward-looking civil and military government space program. Both of these have been neglected in the 1970's and only partially corrected in the 1980's.

4.0 THE COMMERCIAL DEMAND FOR SPACE TRANSPORTATION

Based on all demand, financial, and other market studies performed by NASA and the aerospace community, at least one full orbiter can be used by the commercial, non-U.S. Government, demand for space transportation.

4.1 OVERALL ASSESSMENT

Our marketing studies have indicated a non-USG flight level of anywhere from six to eight flights a year of non-USG demand from 1988 to 1995. As part of its ongoing process of market assessment, SpaceTran asked the Economic Studies Group of Coopers & Lybrand to provide an assessment of non-U.S. Government demand [4]. The SpaceTran estimates, summarized in Table 4.1, show a total of 183 commercial payloads from 1985 to 1995. Figure 4.1 plots several published demand projections, including the Battelle study, from which Coopers & Lybrand drew heavily, in terms of full shuttle equivalent flights. Clearly, projected demand, particularly in the late eighties on, justifies an orbiter to serve commercial users of space transportation.

In the assessment of the demand for payloads for the space shuttle fleet no effort was made to identify specific satellites past that period for which specific launches are known. Data were compiled from a number of sources including the current manifests, a number of other previously published demand analyses (the Battelle study being the best), interviews with selected industry experts, and Coopers & Lybrand background in the launch business. We believe the basic data and modifications to represent an accurate portrayal of the future demand for STS launch services.

A number of assumptions were made in preparing the findings summarized in Table 4.1 and Figure 4.1. Growth curves and actual data are presented. In addition, sensitivity analyses were performed on the data that show the impact of various possible scenarios.

In general, the forecasts of future demand present a strong case for the need of at least one, and possibly more orbiters for commercial uses. The growth in demand is relatively steady. There is a tendency for demand to reach certain peaks due to replacement of existing equipment in space and other factors.

4.2 SPACE SHUTTLE UNIQUE DEMANDS

One of the more uncertain—and promising questions in the demand for space shuttle flights is the use of the space shuttle by new space technologies making use of the unique features of the space shuttle.

Drawing heavily on the assessment made by Coopers & Lybrand for SpaceTran [4], the following can be concluded:

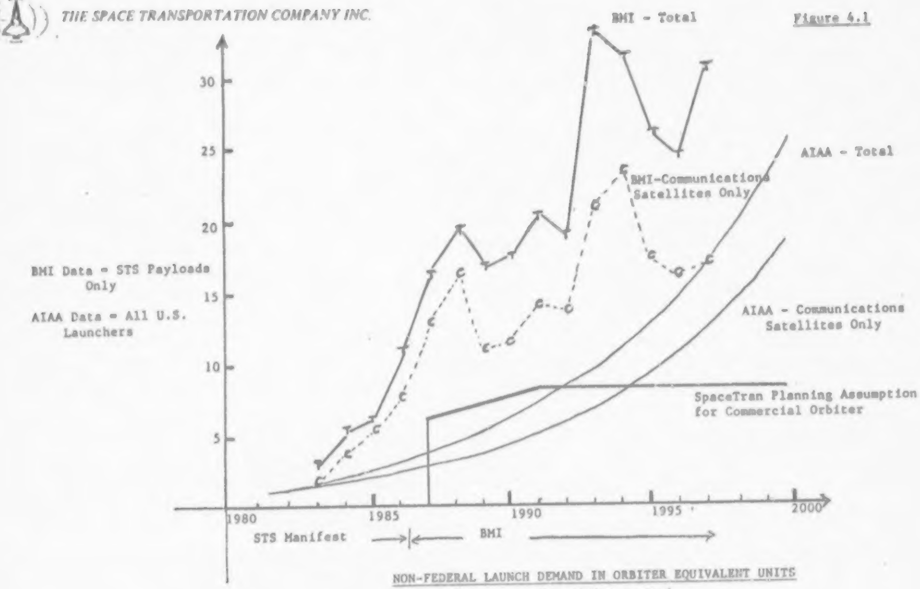
Between the years 1983 and 2000, a convergence of economic, technical and governmental/policy factors will determine the launch demand arising from domestic, noncommunications, commercial applications of space. The prerequisite conditions for commercial uses of space are fundamental. Expensive, long-term and high-risk space technologies must not only be justified by a reasonable expectation of payoff and future profit, but must also be more profitable than ground-based alternatives.

TABLE 4.1.—SPACETRAN MARKET ASSESSMENT, 1985—95; ESTIMATED NUMBER OF COMMERCIAL PAYLOADS PER YEAR BY CLASS OF PAYLOAD—MEAN VALUE [1]

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Titan 34B or Delta class	15	18	15	18	18	14	11	17	21	22	18
Atlas Centaur class	2	3	3	8	5	6	7	3	7	3	7
Titan 34D class	2	2	3	3	3	4	3	1	3	2	2
STS class	3	5	2	4	3	3	3	4	7	9	6

[1] Based on a Coopers & Lybrand study performed for SpaceTran.

Figure 4.1



NON-FEDERAL LAUNCH DEMAND IN ORBITER EQUIVALENT UNITS
(at 100% Capacity)

Sources: Battelle Memorial Institute, "Outside Users Payload Model", July 1982.
American Institute of Aeronautics and Astronautics, "Projection of Non-Federal Demand for Space Transportation Services Through 2000", January 1981.

Payload demand projections for this category of space applications vary widely. The extent and nature of the government's involvement in space—and a policy of active space commerialization—will be important determinants. Materials processing in space (MPS), in particular, has tremendous growth potential through the end of this century.

During the next 20 years the materials testing and processing industry may begin to flourish. "The key to MPS development" contends the U.S. Office of Technology (OTA) "is the space shuttle transportation system." At the same time, the impact of a burgeoning MPS industry on launch demand, STS in particular, would be substantial. The unique properties of outer space, especially microgravity, enables materials such as semiconductor crystals, various pharmaceuticals and metal alloys to be manufactured with greater precision and fewer defects than those produced on earth. MPS may also result in some materials which cannot be made on earth at all.

Most of the early materials processing and testing was expected to be performed on Spacelab, a NASA and European Space Agency (ESA) joint venture. Current scenarios now envision this work taking place on both manned and unmanned space facilities as well as on the shuttle itself.

U.S. private sector activity in this field is projected to increase dramaticaly due primarily to unexpectedly good test results and the increasing flexibility and popularity of Joint Endeavor Agreements (JEA) between NASA and industry. Through the ESA's Retrieval Carrier (RC) program, the Europeans are also committed to augmenting Spacelab's scheduled MPS activities.

There are four principal space shuttle materials processing related services:

(1) Transporting materials into space to construct unmanned space platforms, manned space stations and low earth orbit factories; (2) Periodically refueling MPS space facilities; (3) Periodically collecting or "harvesting" processed materials from "free-floating" labs and transporting them back to earth; and (4) Operating as a short to medium term space lab or factory itself.

While there is cause for optimism, there is no certainty that materials processing in space will become a thriving commercial industry before the year 2000. The potential obstacles to MPS success are typical of extremely high risk endeavors. The most critical barriers in this case are economic, technical and government policy related. They include:

Economic

Few space projects are currently competitive with other investment opportunities.

Possibility that unique space conditions, particularly microgravity, could be cost-effectively replicated on earth or cheaper substitutes for proposed MPS products be developed.

Many proposed space products lack clearly defined or proven markets.

Technical

MPS technologies are insufficiently proven. It is uncertain whether the 8 hours of in-space research to date can be translated into successful, long-term, and massive scale developments.

Power requirements for space laboratory ovens may be excessive.

Government policy

Fundamental questions concern government space commercialization policy—including space transportation and intellectual property rights.

It is highly probable that a large portion of the planned government sponsored MPS activity can be shifted to the private sector. Certainly, if the MPS industry overcomes the potential obstacles and begins to thrive, the impact on space shuttle launch demand before the year 2000 could be tremendous. Payload projections range dramatically from 42 to 234. The space shuttle would account for 100 percent of the total [4].

4.3 THE ROLE OF THE PRIVATE SECTOR IN EXPANDING NON-U.S. GOVERNMENT DEMAND

To the extent that there is commercial, non-U.S. Government demand for space shuttle launch services, the private sector of the United States should—and can—fund the additional capacity required to meet the commercial demand. To this end, the Space Transportation Company Inc, has proposed to NASA that it fund a commercial orbiter with up to $1 billion in funds from the U.S. private sector.

However, the commercial demand for space shuttle flights will not develop "automatically." Competition to the shuttle can be expected from European as well as Japanese launch systems in the late 1980's and 1990's as well as possibly from the entry of the U.S.S.R. providing space launches commercially in world markets.

For the United States to capture its "share" in world markets of space transportion, it needs an aggressive, commercial approach to marketing space transportation systems, very much along the lines of the example set by the Europeans with Arianespace.

The key components needed in a successful worldwide marketing of U.S. capabilities are: schedule certainty (expendable launch vehicle backups as insurance against operational difficulties in the STS fleet), financing of space launches and missions, insurance of launches and missions, "in-place" marketing and support of U.S. STS capabilities and joint ventures with space users to share rights and rewards. The presence of an entity to supply these services in a market environment will in itself increase non-U.S. Government demand for space transportation. Launch services will become more accessible, and the potential of space will be opened to new space users.

It makes sense—for a variety of reasons including economics, accountability, stimulation of the commercialization of the space program, and world marketing of U.S. space transportation capabilities—to have a private funding of Orbiter V, as well as the provision of commercial backup capabilities for non-USG users of the space shuttle system; it makes less sense to have the U.S. Government fund an additional space shuttle orbiter other than to provide capacity to accommodate non-USG users on the shuttle fleet, in direct competition with proposed commercial ventures.

5.0 IMPACT OF THE ABSENCE OF ORBITER V

If the procurement of orbiters were limited to four—possibly with a view to concentrate on making these four vehicles fully operational before proceeding to a "next generation" procurement—the adverse impacts would be mostly economic.

5.1 SHUTTLE COST PER FLIGHT

Without the ongoing procurement of improved orbiters (five and beyond), the direct operations cost for shuttle launches will make the shuttle clearly uncompetitive in world markets: over 12 years, the operations cost per flight will be at least $120 million (1983 dollars, or $57 million 1975 dollars).

With the reduced flight level implied by a four-orbiter fleet—say 23 flights in 1989—the cost per flight may substantially exceed even this number.

The combination of these two factors—freezing of orbiter procurement and reduced flight rates throughout the 1980's to below 25 per year—make the shuttle economically uncompetitive in this decade. Direct subsidization of additive (incremental) operations cost may be required from 1986 to 1988.

5.2 LOSS OF WORLD MARKET SHARE

The effect of high projected cost per flight will be several, among them the loss of a substantial part of the world market to competing launch systems of other nations in the late 1980's and 1990's. This transfer will occur because commercial users will have to assure themselves of launch certainty—without government preemption—and reasonable user charges for launch services. The worldwide market is at least a $10 billion market worldwide. With a four orbiter fleet, and without U.S. commercial ELV's, non-U.S. Government users will be forced to increasingly use foreign launch services.

5.3 INCREASED NEED FOR AN EXPENDABLE LAUNCH VEHICLE BACKUP

Even with—and certainly without—Orbiter V, a U.S. ELV backup to the space shuttle is needed throughout the 1980's and possibly well into the 1990's. There are two principal reasons:

The grounding of the orbiter fleet is substantially different from the "grounding" of expendables or the grounding, for that matter, of aircraft, be they civilian or military. With only four orbiters, the "law of large numbers" statistically simply does not apply, with such a limited fleet size, meaning that whatever the flight success of NASA between 1982-87, even when full operations capability is achieved beyond 1987, no reliable inference can be made on the non-occurrence of a fleet grounding for a substantial time.

The key economic rationale for the space shuttle was the new capabilities this system would bring to the conduct of space missions. In 1971, we called these aspects "payload effects"—the growth of payloads to larger size, payload standardization, in-orbit checkout, in-orbit refurbishment, return of payloads and products, and revisits of payloads such as the space telescope. The commercial sector to date has not availed itself of these growth capabilities even for current technology communications satellites because multibillion dollar developments cannot be made relying solely on one transportation system—with four vehicles at that. A shuttle equivalent backup at least to LEO is necessary before one will see the expansion of the commercial sector to make full use of the space shuttle.

If launch assurance (by expendable backups) is not given by the U.S. market, invariably the Arianespace vehicles of the Europeans will become the de facto backup system to the U.S. STS; Arianespace may become in many cases the primary system with the shuttle serving only as a backup to commercial users in world markets.

5.4 WHICH U.S. EXPENDABLE LAUNCH VEHICLE FOR SHUTTLE BACKUP?

The choice of a commercial backup for the space shuttle clearly has a variety of U.S. systems to choose from, among them the Delta System, the Atlas/Centaur system possibly upgraded to accomplish Intelsat VI, HS393 and some direct broadcast satellite applications—and the Titan system. Such competition will have to consider the following:

Any U.S. ELV system has to be competitive in world markets with other expendable launch systems as long as such other systems are not subsidized outright.

The U.S. ELV should be capable of providing complete backup to the space shuttle system in terms of payload mass, volume, and launch environment.

Any commercial ELV will be less advantageous than projected shuttle launch prices from 1986–88 based on user charges of $71 million per shuttle flight (1982 dollars). However, a commercial ELV may put an "upper ceiling" on likely future space shuttle user charge increases in 1986 to 1988 and certainly beyond 1988.

Ideally, a U.S. ELV will provide the Air Force with a continued expendable backup option to the space shuttle system, possibly well into the 1990's, without imposing large payload modification costs on the Air Force for the use of such ELV's.

Commercial ELV ventures will allow NASA to phase out future government funding of all expendable launch vehicle systems.

The U.S. Government should not stand in the way of an early, efficient commercialization of U.S. ELV's to meet foreign competition on equal ground. The U.S. Government, as part of this process, should not impose user charges on U.S. ELV's which are not imposed on either the space shuttle or by foreign ELV organizations. These include principally fees for existing government space facilities and services. The total market for U.S. launch services will be substantially larger when the STS is combined with commercial ELV's in this critical transition phase.

Commercial U.S. ELV's may substantially delay and discourage all foreign ELV competition in world markets.

5.5 ORBITER V AND A SIGNIFICANT NEW SPACE GOAL FOR NASA

Even if government funding for Orbiter V were feasible, we still submit that equivalent funds would be better invested by NASA in significant new technology initiatives than in building one more orbiter when this orbiter could be provided by the private sector.

Such new technology initiatives certainly ought to include (1) large space structures, (2) orbit transfer vehicles, (3) civil space applications, and (4) civil aeronautics initiatives. These initiatives will add to the U.S. technology base in the late 1980's and 1990's, whereas one more orbiter will not.

Important new technology initiatives might be "squeezed out," postponed or altogether foregone by Orbiter V funding has to come from the Federal Budget. On the other hand, the example set by NASA in private sector participation in a significant part of the U.S. space program may provide a powerful incentive to the Administration and Congress to proceed with significant new technology initiatives so that similar examples of commercial phaseover and success may be set in the future, based on these same principles.

5.6 SHUTTLE TECHNOLOGY EVOLUTION

Related to the question of whether to continue orbiter production capabilities or close the production lines is the question of the development and maintenance of the orbiter technology base: is a continuation of the current space shuttle design by acquisition of additional orbiters in the overall national interest or should the production of orbiters be frozen with the current number until initiating a second generation space shuttle.

Components in the current space shuttle design can be upgraded gradually, in an evolutionary shuttle technology program so as to make a "closing" of space shuttle production of the current design undesirable. The current shuttle design can be evolved gradually to a substantially improved space shuttle version by the mid-1990's without a dramatic cut in production lines and a total redesign effort.

Substantial improvements are possible on individual components of the current space shuttle system, such as the external tanks, the solid rocket boosters (possibly to be replaced by pressure-fed systems), improvements in the thermal protection system—without a radical redesign of the shuttle vehicle. Included therein can be a gradual upgrading of engine performance and engine life. The active maintenance of an evolutionary space shuttle technology program would clearly be of great advantage to the nation. Not all of these improvements necessarily warrant the acquisition of an additional orbiter.

The advantages of procuring Orbiter V can be summarized as follows:

Insurance against catastrophic loss(es) of Orbiters I through IV.

Insurance against unforeseen operational difficulties affecting availability of specific orbiters or the orbiter fleet.

Assurance of a reasonable cost per flight in that the total cost added by Orbiter V to STS operations costs is not significant when compared to the ability of the fleet to accommodate all the traffic for STS on time.

Insurance against future demand growth for STS beyond the capacity of a four-orbiter fleet.

More cost effective operations from improvements in Orbiter V arising from earlier experience in the space shuttle flight program.

Assurance that all payloads scheduled to be launched on STS can be launched (65,000 pounds capability from the Eastern Test Range (ETR) and 40,000 pounds capacity from the Western Test Range (WTR), payload return capability, etc.).

Assurance of continued orbiter production capability into the late 1980's and 1990's.

6.0 NEED FOR AN AFFIRMATION OF U.S. SPACE GOALS AND ENTERPRISE

The opportunity—and the status—for the United States in space enterprise are many and challenging. However, these opportunities are not realized if left to themselves without combining government and private enterprise, without government assuming leadership for new technolgoy space goals and without the common sector assuming its share to realize these opportunities in new space markets. This new direction cannot be left to the "Invisible hand." Clearly, a resolution of the mix of U.S. space transportation capabilities—Orbiter V and common ELV's—is needed. More important, U.S. space enterprise has to combine government and private initiatives in space applications and space transportation.

Whereas the 1950's and 1960's represented an era of enterprise, expansion, risk-taking, and growth, the 1970's devolved as a decade of retrenchment, cutbacks, monetary illusion (created by inflation), limited risk-taking, and management by "stretch-out" rather than accomplishment. Funding of R&D has been cut back from over 3 percent of GNP in recent years, the reduction of 1 percent coming from cutbacks in federal funding of R&D and thus principally cutbacks in aerospace R&D.

In short, whether by accident or design, we experienced a period of disinterested policy, the consequences of which now show up in the strategic balance and changing patterns in aerospace world trade.

At the heart of this retrenchment was the U.S. space program. The vast successes of the 1960's—in manned space flight, the space communications program, and space science—created a foundation for the decades to follow, but the 1970's saw a singular failure to capitalize on it. From an era of challenging space goals we wandered into indecision, confusion, lack of purpose, or imposed inactivity, mostly due to budgetary and fiscal constraints. Also the notion was held by technological Luddites (for want of a better term) that the federal budget deficit and all other societal issues can be solved by cutting back aerospace programs, such as Orbiter V.

The United States should have used its space technology base of the late 1960's by making its space program a principal component of its technological, economic, and foreign policies in the 1970's. For two principal reasons the United States has not done so:

NASA was not given a challenging new space goal and program for the 1980's to go—in parallel—with the space shuttle development. Space transportation systems are means and not goals, and as such they have to be put to some broader purpose and use. This use was not defined in the 1970's.

The U.S. did not create a program to put its vast market forces in pursuit of opportunities to exploit space on a worldwide basis.

Both of these causes of failure have to be corrected.

What the precise U.S. space goal and program should be is currently under active consideration by the U.S. Government. From an economic perspective, clearly, the geosynchronous orbit holds the greatest promise: the information sector of the United States and worldwide will constitute a major part of economic activities in the 1990's. It is also the part where the United States still leads in space, and where the United States has the possibility of further significant breakthroughs with large space structure technologies—platforms—in low and geosynchronous earth orbits.

Establishing a new U.S. space goal, especially for NASA, will not in itself bring about the full development of U.S. space program opportunities. We must restructure the very basis and mode of space operations and applications. We must bring about accountability in space programs, government and industry cooperation to the benefit of the U.S. economy, and the institutional setting to allow full private as well as government initiatives in pursuit of space opportunities.

The U.S. aerospace industry has been the most dynamic and innovative sector of U.S. industry in world markets, and is the largest contributor to net trade (exports minus imports): for every dollar of sales aerospace industry makes a net export contribution of more than 20 cents; and for every dollar of sales, aerospace spends 20 cents on research, development and testing (see Figure 6). This peformance leads by far any other sector of U.S. industry. [4, p. 22.] Aerospace industry has been for some time an example of successful government and industry cooperation. Let us continue this example in space matters.

At stake in world space markets are anywhere from $20–50 billion in commercial investments between now and 1995, about one-third of that are space transportation costs ($10 to 15 billion), one-third payload costs, and one-third are ground systems costs.

Of this total commercial world market, about one-half may be open to competition by the United States and the other leading industrial regions (Europe, Japan). It is time for the United States to set up economic structures that will be able to compete in such markets. Europe has done so in Arianespace—a commercial entity.

A commercial approach is fundamental to the success of the United States in world space markets: Aerospace companies to date have done an outstanding job in world markets. The aerospace sector is the most successful segment of the United States in world trade. Nothing has happened to suggest that a govenment agency may do a better job than industry can provide. Hence, private institutions should be allowed—indeed encouraged—to go forward and assume these functions.

In terms of space transportation this applies to the commercialization of expendable launch vehicles, as well as Orbiter V.

In the context of such a reaffirmation and redirection of the U.S. space effort the question of the need for—and the funding of—Orbiter V will become more obvious and may well be left to the marketplace.

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NOTE: References are noted in the text without footnotes; reference and page numbers appear in the text.

Senator TRIBLE. Thank you, Dr. Heiss. Thank you, gentlemen, for your testimony today.

Let me direct a question to the entire panel. And that question is very directly in your professional judgment: Should the U.S. Government finance a fifth orbiter, possibly at the expense of new scientific and technological initiatives, or should a fifth orbiter be financed by commercial venture?

Dr. ROSEN. Mr. Chairman, the AIAA has taken a consistent position over the years that a fifth orbiter will be required. Our position this year is that there is no clear evidence that that commitment must be made in fiscal year 1984. There is clear evidence, however, that the subcontractors and vendors must be sustained through fiscal year 1984 at a rate which will allow us to make that commitment in the future. But we have seen no long-term change in our forecast for demand for Shuttle traffic which would lead us to change our position from that which we had previously stated, and that is that at least five orbiters will be required for the fleet.

Senator TRIBLE. Would anyone else care to add to that?

Dr. HEISS. Well, I would think first the question ought to be answered from a national perspective: Do we need an orbiter now, a fifth one, or can that decision be delayed? The question of whether there is Government funding or private funding is really secondary to that question.

An important issue related to it is the commercialization of ELV's, which could probably take up some of the slack and uncertainty or growth expected in demand later on in this decade without having to lose these markets to foreign competition, without an orbiter V.

But the key question to ask I believe ought to go as follows: With $1 billion added to space activities, is the Nation better off if NASA funds one more orbiter or would NASA and the Nation be better off if that same billion from Government funds was spent on new initiatives, be it in aerospace technology, aeronautics, and in particular with regard to a new space goal, civil space goal, as against funding one more orbiter, if the private sector can fund orbiter V? And in that context alone, I think clearly we prefer private funding to Government funding of orbiter V.

Dr. YARYMOVYCH. There is a question of timeliness in order to retain the critical skills and the critical elements of the team. As we were saying, although a full commitment now to a fifth orbiter depends on further examination of the future, a full commitment now to keep the line open is nececessary.

And when we talk about now, we are talking about time periods of April or early summer of this year, 1983. If no funding is forthcomming, certain portions of the contractor team will be shut down and certain critical skills will have to be laid off and lost and to regain them later, should we change our minds that we after all do need this orbiter, will be very costly. So the question of whether the Government pays for it or the commercial enterprise pays for it is certainly a subsidiary question.

The next problem is how fast can a commercial enterprise get its funds together to support this program now?

Senator TRIBLE. You are testifying then that a decision must be made by the spring in order to keep the production line and support facilities and personnel and staff in place?

Dr. YARYMOVYCH. Well, it is a capability that would be eroding with time. Certain things are more critical than others that have to be kept on line earlier than others because they are going through a phase-out as the fourth orbiter production is terminating.

Senator TRIBLE. Consistent with that observation, as we consider the decision to procure a fifth orbiter, the ability to build that orbiter diminishes with time. What is your view of the cost if we initiated, if we made the decision in fiscal year 1983 or if we made the decision in 1984 or in 1985? Are you in a position to address that question of cost?

Dr. ROSEN. Sir, let me say the AIAA is not in a position as a corporate body to address that issue. However, we are fortunate in that this year our president, Dr. Yarymovych, is intimately involved with the Shuttle program and is a vice president at Rockwell. I think in that capacity might be able to give you some data.

Senator TRIBLE. We would be happy to accept your testimony wearing that hat.

Dr. YARYMOVYCH. Bear in mind that, of course, NASA is the final authority on cost figures, and we can only be approximate about these things. But I believe in the current budget projection of NASA there is a request for $100 million for the so-called structural and component spares to go into fiscal year 1984.

Now, that certainly will go a long way to retain critical skills, and we believe that is essential. A figure that we like to quote for fiscal year 1984 is $170 million, which retains a much larger complement of critical skills to maintain the ability to enter into a commitment for a fifth orbiter in fiscal year 1985, should that decision be made later.

Now, you may know that a full fifth orbiter go-ahead without just retention of skills per se, but a commitment to the orbiter is anywhere in the vicinity of $250 million in 1984.

Senator TRIBLE. Thank you, sir.

Dr. HEISS. May I? I think one ought to distinguish between the vehicle cost of orbiter V on one side and the maintenance of production capability on the other. I think the vehicle cost of orbiter V is about $1 billion in 1982 dollars anytime basically. The big cost is to maintain production capability and that is very substantial. And they are in the context of whether orbiter V should be procured now or later.

There are probably two philosophies. One is a gradual evolutionary improvement of space transportation technology, and within that context orbiter V clearly is required at some point. And back in 1971 when NASA chose this orbiter it has specifically in mind such gradual improvement rather than to go through a fully reusable system in 1971.

The other philosophy would be as follows: Freeze the procurement of orbiters at four vehicles, see how it works and when it works fully, and then go to a new batch procurement of the next generation orbiter rather than the next generation, say, a derivative which would incorporate what we learned now and in the next few years.

And I do not know what the answer to those two questions is.

Senator TRIBLE. Any other additions? Thank you, gentlemen. Let me ask you a further question. NASA has decided to phase out its expendable launch vehicles. Is there a justifiable concern that abandoning these ELV's and relying totally on a four-orbiter fleet would leave NASA particularly vulnerable to a loss of an orbiter or to critical spare parts?

Dr. ROSEN. Sir, I think the clear answer to that question has to be yes. There is justifiable concern that without a continuing ELV backup, you may run into some problems in providing launch services to the varied user communities. I think we all recognize that the decision to phase out ELV's at any point in time is based primarily on what we can afford to buy, not on what we would like to have. So the answer has to be yes.

Senator TRIBLE. All right, gentlemen, I have a series of additional questions. What I would like to do is propound some of those to you later for the record.

I thank you very much for being here today.

Dr. Willis Shapley and Dr. Thomas Donahue are invited to come forward. And this panel will present testimony on space sciences and applications. And you are welcome, gentlemen. Good morning, gentlemen. Your testimony will be made a part of the record. So you are invited to summarize that testimony or perhaps propound additional thoughts or observations. We are pleased that you are here today.

STATEMENTS OF DR. WILLIS H. SHAPLEY, SPACE APPLICATION BOARD, NATIONAL RESEARCH COUNCIL; AND DR. THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL ACADEMY OF SCIENCES

Dr. SHAPLEY. Thank you, Mr. Chairman. My name is Willis Shapley, and I am here today as the representative of the Space Applications Board of the National Research Council. I was formerly the Associate Deputy Administrator at NASA and am now a private consultant. We appreciate very much the opportunity and the invitation to present the views of the Space Applications Board on NASA and related programs for civil space applications. I am substituting for our chairman, Mr. George Harter, who regrets he is not able to be here today.

As you suggested, in the interest of time I will present only the highlights of the prepared statement you have before you.

With respect to the NASA budget, we recognize that the 1984 budget is an improvement over the budgets presented to Congress in recent previous years. The complete moratorium on new starts has ended. The administration has now given its approval to the advanced communication satellite technology program which this subcommittee and the Congress approved last year.

There seems to be a green light for moving ahead with UARS, the upper atmosphere research satellite, which has applications as well as scientific significance. However, several matters concern us. And we feel that some adjustments by Congress could result in a better program for the Nation.

In land remote sensing, the 1984 budgets of NASA and NOAA appear to be premised on the rapid success in transfering the Nation's civil operational remote sensing satellites to the private sector. A Presidential decision was finally made a few days ago on the approach the administration proposes be taken in effecting this transfer.

However, the administration has not yet come forward with details of its recommendations on crucial matters such as, one, the terms and conditions on which bids from prospective contractors will be requested; second, the degree of Federal subsidy that will be considered acceptable; third, the implementing legislation Congress will be asked to enact; fourth, the plans for the transition from Government to commerical operations; and finally, the changes necessary in the fiscal year 1983 and 1984 budgets.

Until these details become known, the administration's commercialization proposal cannot be judged and the adequacy of the NASA and NOAA 1984 budgets for remote sensing now before Congress cannot be properly assessed.

The Space Applications Board has endorsed the movement toward commercialization of at least some parts of the U.S. civil remote sensing enterprise. We have emphasized that a major market for remotely sensed data will not develop without speedy data handling and assurance of continuity of data.

We have recommended that the Federal Government should proceed with a transfer of a data reduction and data handling parts of the Landsat program to the private sector as quickly as economically possible but should defer attempts to transfer to the private enterprise the space portion of the Landsat system.

We have also recommended that the Federal Government conduct a vigorous program of experiments and other technology transfer activities to assist the private sector in realizing the potential benefits of civil remote sensing and should also pursue an aggressive R&D program on remote sensing technology applicable to civil purposes.

Mr. Chairman, we have had reservations on the desirability and feasibility of attempting to transfer both space and ground segments to the private sector as the administration is now proposing. But we would certainly not want to prejudge the administration's proposals. I am sure the Space Applications Board and, of course, this subcommittee will give them careful consideration when they are spelled out in more detail.

In its consideration of the thorny questions relating to commercialization, we would hope that the subcommittee would give specific attention to assuring that the NASA and NOAA budgets contain adequate provisions for maintaining continuity of both operations and research and development in land remote sensing.

Leadtimes for replacement of Landsat satellites are running out, if indeed they have not already done so. If a commercialization plan is approved, we feel that contingency provisions should be made in the budget for preserving continuity in the event that negotiations for commercialization fall through, as well they might, or are subject to further delay, which is perhaps even more probable. Mr. Chairman, we should not lose our civil remote sensing capabilities and benefits by default.

In the meteorological satellite area, the principal concern of the Space Applications Board is that there does not appear to be any provision in either the NASA or the NOAA budgets for continued development and tests of improved environmental sensors for meteorological satellites. We would hope that the subcommittee would examine this situation carefully and see what should be done.

There is also doubt, Mr. Chairman, whether the NOAA budget provides for adequate continuity in procurement and operation of operational civil weather satellites, especially in the event that the proposed handover to the private sector takes longer than the administration expects or does not take place.

While again not wishing to prejudge the merits of the administration's proposals before the details are known, I must state that the Space Applications Board has questioned the advisability of commercializing meteorological satellites, a service for which the Federal Government itself is the principal customer.

In communications satellites, Mr. Chairman, we are pleased that the ACTS advanced communication technology satellite program is included in the fiscal year 1984 budget and hope that Congress will continue to support it. We believe that NASA should also be sponsoring communications technology development in some other high-risk areas. Some suggestions are noted in my prepared statement.

In materials processing, the Space Applications Board endorses the NASA program as now oriented, but has some concern that as presently funded it may not make adequate provision for flight experiments on the Space Shuttle.

The board sees great potential in ocean remote sensing for both applications and scientific purposes. We would hope that an ocean remote sensing satellite will be given a high priority for a future new start.

In closing, Mr. Chairman, I would like to stress three points: first, the importance of maintaining a strong level of funding for research and analysis in the applications area. While this is not as glamorous as the major hardware projects, these activities are essential to support the progress in the overall space applications program.

Second, it is especially important that NASA's programs include studies and experiments directly involving the potential users of space applications. NASA's development of new technologies for space applications must be guided by a realistical practical understanding of the needs and problems of prospective users. Conversely, potential users need to be made more aware of the possible ways in which space applications technology can contribute to their needs and interests.

Finally, I want to stress the Board's strong belief that space applications is a key area of NASA's activities. It plays an essential role in insuring that the Nation actually receives practical civil benefits from our tremendous and continuing investments in space technology. In many areas, such as land remote sensing and communications, it has become clear that Government action through NASA, NOAA or other agencies can make the difference between the realization of benefits or their loss, either to a foreign competitor or altogether.

In these areas, we must all work together to find ways for the Government, jointly with the private sector where feasible, to protect the broader national interest and preserve a leadership position for the United States.

This concludes my statement, Mr. Chairman.

[The statement follows:]

STATEMENT OF DR. WILLIS H. SHAPLEY, MEMBER, SPACE APPLICATIONS BOARD, NATIONAL RESEARCH COUNCIL

Mr. Chairman and members of the subcommittee, on behalf of the chairman and members of the National Research Council's Space Applications Board, I want to thank you for your invitation to present the views of the Board on the nation's programs directed at practical uses of space systems by the civil community.

Mr. George Harter, chairman of the Space Applications Board, regrets that he is not able to be here today. He and the Board have asked me to appear here in his stead. My statement has been prepared in collaboration with him and is intended to present the consensus of the Board.

The Space Applications Board was formed by the National Academy of Engineering in 1972, and is now a part of the National Research Council, the operating organization of the National Academies of Science and Engineering. The Board's functions are to help formulate the nation's program for practical applications of space systems, to give independent advice to NASA and other agencies, and to assist in broadening the interest and understanding of industry, universities, government, and the public in practical applications of space technology.

Mr. Chairman, as you requested in your letter, I will comment briefly on the fiscal year 1984 budget request for NASA's space applications activities and address some areas that are of concern to the Space Applications Board.

The Board was briefed on NASA's fiscal year 1984 space applications budget at its last meeting on February 16, 1983. While we have not reviewed the budget in detail, I can give you the Board's reaction to the decisions reflected in the budget.

First, we recognize that the fiscal year 1984 budget is an improvement over the budgets presented to Congress in recent previous years. The complete moratorium on new starts has ended. The administration has now given its approval to the advanced communications satellite technology program which this Subcommittee and the Congress approved last year. There seems to be a green light for moving ahead with UARS—the upper atmosphere research satellite—which has applications as well as scientific significance.

However, several matters concern us. We are not in a position to make specific recommendations on the budget but would like to bring to your attention some questions which we believe you should address and take apppropriate action on in your own review. We recognize the need for constraints on the total budget but feel that, as in previous years, some fine tuning adjustments by the Congress could result in a better program for the nation.

I will comment, in order, on the land remote sensing (Landsat) and meteorological satellite areas, then on communications satellites, materials processing in space, and remote sensing of the oceans. In conclusion I will offer some general observations on the space applications program.

LAND REMOTE SENSING

In land remote sensing, the fiscal year 1984 budgets of NASA and NOAA appear to be premised on rapid success in transferring the nation's civil operational remote sensing satellites to the private sector. A Presidential decision was finally made, a few days ago, on the approach the administration proposes be taken in effecting this transfer. However, the administration has not yet come forward, as far as we know, with details of its recommendations on crucial matters such as the terms and conditions on which bids from prospective contractors will be requested, the degree of federal subsidy that will be considered acceptable, the implementing legislation Congress will be asked to enact, the plans for the transition from government to commercial operations, and the changes necessary in the fiscal year 1983 and fiscal year 1984 budgets. Until these details become known, the administration's commercialization proposal cannot be judged and the adequacy of the NASA and NOAA fiscal year 1984 budgets for remote sensing now before Congress cannot be assessed.

As the Subcommittee is well aware, the commercialization of civil remote sensing raises many controversial and difficult questions that have been the subject of seemingly endless study and discussion for many years. Now, however, lead-times for maintaining continuity of service after Landsats D and D-prime are running out, if they have not already done so. Our foreign competitors—France and Japan—are continuing to move ahead. It is essential therefore, that clear decisions be made at this session of Congress either (1) to proceed with a commercialization plan that both protects our national interests and provides a workable framework for attracting effective private participation or (2) to make appropriate adjustments in the 1984 budget of NASA and NOAA to ensure that the U.S. does not forego the benefits of civil remote sensing from space nor abandon to foreign competitors our leadership in this field—in which we have invested so much and have had so much technical success.

The Space Applications Board has been active since its establishment in studying and reviewing the problems of civil land remote sensing. In our reports and testimony we have endorsed the movement toward commercialization of at least some parts of the U.S. civil remote sensing enterprise. Last year, for example, we emphasized in testimony before the House Subcommittee on Space Science and Applications that a major market for remotely sensed data could not develop without speedy data handling and assurance of continuity of data. We recommended that the federal government should proceed with the transfer of the data reduction and data handling parts of the Landsat program to the private sector as quickly as economically possible, but should defer attempts to transfer to private enterprise the space portion of the Landsat system. We also recommended that the federal government conduct a vigorous program of experiments and other technology transfer activites to assist the private sector, in realizing the potential benefits of civil remote sensing and also pursue an aggressive R&D program on remote sensing technology applicable to civil purposes.

We hope that these views will be taken into consideration in Congressional deliberations and note that similar views were expressed in the report of the Secretary of Commerce's Land Remote Sensing Satellite Advisory Committee, chaired by Michael Halbouty, released last fall. While we have had reservations on the desirability and feasibility of attempting to transfer both space and ground segments to the private sector as the administration is now proposing, we would certainly not want to prejudge the administration's proposals. I am sure the Space Applications Board will give them careful consideration when they are spelled out in more detail.

In its consideration of the thorny questions relating to commercialization, we would hope that the Subcommittee would give specific attention to assuring that the NASA and NOAA budgets contain adequate provision for maintaining continuity of both operations and R&D in land remote sensing. If a commercialization plan is approved, we feel that contigency provisions should be made in the budget for preserving continuity in the event that negotiations for commercialization fall through or are subject to further delay.

A final point on land remote sensing. We note that the fiscal year 1984 Budget proposes eliminating the NASA contribution to Agristars, the triagency (Agriculture, NOAA and NASA) program, for using Landsat data in surveying and forecasting production of selected crops. The success of this program depends on the collaboration of all three of the agencies, each providing essential special capabilities. In previous years each agency, including NASA, has provided its share of the funding required, in accordance with an inter-agency agreement. We believe that the Subcommittee should assure itself that the total funding provided for Agristars in fiscal year 1984 is sufficient for continued progress in the program and that any change in the funding pattern does not serve to undercut what appears to be an effective inter-agency working arrangement.

METEOROLOGICAL SATELLITES

In the meteorological area, the principal concern of the Space Applications Board is that there does not appear to be provision in either the NASA or the NOAA budgets for continued development and test of improved environmental sensors for meteorological satellites. The dislocations forced by the reductions in the NASA and NOAA fiscal year 1982 and fiscal year 1983 budgets have had the unfortunate effect of terminating—or suspending—the excellent partnership arrangement in research and development on meterological satellites that had existed between the two agencies for over 15 years. We would hope that the Subcommittee would examine this situation carefully and take such action as it finds necessary.

There is also doubt whether the NOAA budget provides for adequate continuity in operational civil weather satellites, especially in the event that the proposed handover to the private sector takes longer than the administration expects—or does not take place. While still not wishing to prejudge the merits of the administration's proposals before the details are known, I must state that the Board has questioned the advisability of "commercializing" meteorological satellites, a service for which the federal government itself is the principal customer.

COMMUNICATIONS

As I have already indicated, the Space Applications Board is especially pleased that the President's budget has endorsed ACTS, the Advanced Communications Technology Satellite. In a 1977 report "Federal Research and Development for Satellite Communications," the SAB pointed out the urgent need for NASA to resume work in this area. Other groups, industry representatives and Congress concurred, with the result that NASA undertook a new program of applied research, technical development, and requirements studies directed at future civil needs for increased capacity and new civil applications of satellite communications.

It has been clear for some time, Mr. Chairman, that the market for space communications is growing and that orbit crowding will almost certainly preclude meeting the demand at the C-band and KU band frequencies now in use. Meeting future market needs will require new types of satellites operating in the 30/20 gigaHertz band. Our principal foreign competitor (Japan) has also recognized this as the next major area of development in communications satellites and is moving to exploit it.

NASA, the SAB, industry, Congress and now the administration are in agreement (1) that flight test experiments in the 30/20 gigaHertz range are necessary before private sector companies can responsibly move ahead with the actual establishment of communication systems at these frequencies and (2) that the private sector alone could not assume the full cost of mounting such a flight test program.

With advice from the SAB and with strong Congressional support, NASA has now worked out a program approach in which industry will participate actively on a cost sharing basis. We understand that formal Requests for Proposals are about to be released by NASA to industry. We hope that the Subcommittee and the Congress will continue to support the ACTS program as a vital contribution to advancing space technology which can help preserve for the United States a preeminent position in satellite communications.

Beyond ACTS, however, a broad range of new technologies is needed to respond to the diverse requirements of the very competitive and rapidly changing communications industry. The Space Applications Board believes that NASA should be sponsoring very high risk technology development which is beyond the capability of the industry. This research should include systems studies of potentially feasible advanced communications systems for new services, such as video conferencing, two-way computer transactions and mobile communications.

We believe that NASA should also emphasize high-risk research and development related to ground terminals. The market for ground terminal equipment is potentially much larger than the market for satellites, and is therefore of prime importance to U.S. industry and to U.S. users. With the advent of all-digital communications systems, ground terminals of the future will require technologies as sophisticated and advanced as those required for satellites. New spectrum-efficient and power-efficient communications techniques offer the possibility of transmitting much more information through a standard satellite transponder.

Intersatellite links may play a major role in future communications satellite systems. We can expect that regional systems employing a number of communications satellites to provide services over wide areas will be linked together by inter-satellite links, providing greater system interconnectivity and eliminating the need to relay satellite messages via ground terminals. Research is needed to study the technical and economic aspects of interlinked satellite systems.

MATERIALS PROCESSING

In the materials processing area, the Board believes that NASA's activities are correctly oriented towards materials science and engineering experiments as recommended by our Committee on Scientific and Technological Aspects of Materials Processing in Space back in 1978. However, we have some concern that the program as presently funded may not make adequate provision for conducting flight experiments using the space shuttle over the next two or three years, in addition to the ground based investigations that have been underway and should continue.

OCEAN REMOTE SENSING

Recently, a panel on ocean operations under the SAB has emphasized—as has the Space Science Board's Committee on Earth Science—the great potential, from both the scientific and applications standpoints, of continuous measurement from satellites of key parameters of the ocean such as surface temperature, currents, wave motion, etc. The truncated Seasat experiments and some short duration Shuttle experiments have confirmed this promise. It is regrettable that the joint NASA-NOAA-Navy "NOSS" program was terminated in 1981 just as it was about to get underway. The Board believes that the initiation of an oceanic remote sensing satellite should be given a high priority for a future new start.

CONCLUSION

Mr. Chairman, this concludes my prepared comments on the major space applications programs. In closing, I would like to stress three points.

First, I would like to stress the importance of maintaining a strong level of funding for research and analysis in the applications area. While not as "glamorous" as major identifiable hardware projects, these activities are essential to support the overall space applications program.

Second, as the SAB has repeatedly stressed, it is especially important that NASA's programs include studies and experiments directly involving potential users of space applications. NASA's development of new technologies for space applications must be guided by a realistic practical understanding of the needs and problems of prospective users, and conversely, potential users need to be made aware of the possible ways in which space applications can contribute to their needs and interests.

Finally, I want to stress the Board's strong belief that space applications is a key area of NASA's activities. It plays an essential role in ensuring that the nation actually receives practical civil benefits from our tremendous and continuing investments in space technology. In many areas, such as land remote sensing and communications, it has become clear that government action, through NASA or other agencies, can make the difference between the realization of benefits or their loss—either to a foreign competitor or altogether. In these areas we must all work together to find ways for the government—jointly with the private sector where feasible—to protect the broader national interests and preserve a leadership position for the United States.

This concludes my statement.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Mr. Shapley, the fiscal year 1984 NASA request contains no funding for Agristars. Supposedly, the applicable research will take place in other agencies. Why is it important that NASA continue to fund Agristars?

Is not the support of the Departments of Agriculture and Commerce sufficient for the continued maintenance of services?

What would be an appropriate fiscal year 1984 level of funding in NASA for Agristars?

Answer. While the Space Applications Board has not reviewed the combined budgets for Agristars in detail, it appears that the total amount included for Agristars in the President's budgets for Agriculture and Commerce is about $10 million short of the total amount required by all three agencies (Agriculture, NOAA and NASA) for effective prosecution of the program. In the circumstances, $10 million short of the total amount required by all three agencies (Agriculture, NOAA and NASA) for effective prosecution of the program. In the circumstances, $10 million would be an appropriate FY 1984 level of funding for NASA, assuming that Congress will approve the amounts requested by Agriculture and NOAA.

Question. Mr. Shapley your testimony indicates your approval of NASA's new Advanced Communications Technology Satellite (ACTS). How does our ACTS program, as this point, measure up to our foreign competition in this field of technology?

This program reportedly will cost NASA $350 million and will operate under a cost/risk sharing arrangement with industry. How much of the total cost would or should private industry assume?

Answer. Members of the Space Applications Board have had indications from a variety of sources that our foreign competitiors have taken a running head start in preparing to exploit the 30–20 Gigahertz technology for satellite communications. They appear to have the full support of their government in their efforts. Our feeling is that with prompt forward motion in the ACTS program, the United States can still expect to be able to complete effectively with them.

With respect to cost sharing the ACTS program, we believe the government should negotiate with the prospective industrial participants to get the private sector to assume as much as possible of the cost of ACTS with due regard for protecting the broader national and public interest.

Question. Mr. Shapley, the field of technology utilization is designed to transfer new NASA developed technology to our civilian sector. The fiscal year 1984 NASA budget request for Technology Utilization declines to $4 million, from a fiscal year 1983 level of $9 million.

Could you comment on the benefits of technology utilization and the impact the reduced funding could have on this program and on its beneficiaries?

Answer. The Space Applications Board has not reviewed the Technology Utilization program proposal in the fiscal year 1984 budget. As a general principle, however, we believe that NASA should make all reasonable efforts to promote the transfer of NASA developed technology to constructive uses in the private sector. We fail to see the rationale for a reduction in these efforts in the fiscal year 1984 budget while at the same time the administration is stressing the importance of high technology to the future of the U.S. economy.

Senator TRIBLE. Dr. Donahue.

Dr. DONAHUE. Mr. Chairman, my name is Thomas Donahue. I am a professor of atmospheric science at the University of Michigan and chairman of the Space Science Board of the National Academy of Sciences. I also shall accept your—follow your suggestion to abbreviate my testimony and omit some portions of my prepared statement, Mr. Chairman.

Thank you for the opportunity to meet with you today to discuss the fiscal year 1984 NASA budget request and how it affects the space sciences. On behalf of the Space Science Board, I am pleased to be able to report that on the whole we are gratified by the level of support for space science expressed in the proposed budget.

From a comparison of the fiscal year 1984 budget request with trends in previous fiscal years and culminating with the fiscal year 1984 budget request, there is evidence that an important shift has taken place in the administration's assessment of the importance of the space science program. Unlike the situation in fiscal year 1983, there is balance among the major space science disciplines in the program. None are threatened with cancellation or eventual demise. Major ongoing development projects are funded adequately. A new start for the planetary program is requested. The contrast with the fiscal year 1983 request for the planetary program needs no emphasis from me. Major study efforts to develop the queue for new start candidates are supported.

I sincerely hope that what we are seeing is the emergence of a period of stability in both the fiscal and programmatic sense. If that is the case, and it will take several years to confirm, we will finally have reached a point where together we can quietly assess the state of this national resource and lay the groundwork for its secure future.

I shall address the question of support for the baseline programs for research and analysis and for mission operations and data analysis for ongoing missions separately, for we have a continuing problem in some of those areas.

To say that the space science community is satisfied with the fiscal year 1984 budget request is an oversimplification and not altogether accurate, given what has happened to the field over the last half-dozen years. The economic imperatives that have constrained the level of overall activity and threatened some of the fields represented in space science have forced a serious discussion of the value to the Nation of doing science in space and raised the question of whether there existed a level at which the future of the field could not be reasonably assured or might not be worth maintaining.

I trust that the debate is ended with this budget submission. I hope this committee and the Congress will see the budget in this same light, so that we can begin the task of reconstituting and rebuilding the U.S. position in space science.

My assessment of the NASA fiscal year 1984 budget request is reinforced by statements that have been made recently by Dr. George Keyworth, Science Advisor to the President. Writing in the February 18 issue of Science magazine, Dr. Keyworth includes space science among the fields selected for special emphasis in the Federal R&D programs in fiscal year 1984 as likely to have the greatest long-term impacts on new technologies.

Let me now turn to some comments on the details in the fiscal year 1984 budget request. The request for an augmentation in the Explorer line item is in accordance with longstanding recommendations of the Space Science Board and its Committees on Space Astronomy and Astrophysics and Solar and Space Physics, as well as those of the Astronomy Survey Committee chaired by Prof. George Field.

Probably the most important effect of this augmentation will be to allow the Agency to increase the frequency of flight opportunities in the Explorer program. If space science is suffering a malaise these days—and it is—this state is a consequence of the dramatic decrease in the rate at which space science missions have been launched during the past decade and are presently scheduled for launch.

The delays associated with changing from expendable launch vehicles to those of the space transportation system are partly responsible for the retardation. Associated with the decrease in the rate of flight opportunities has also been a tendency for missions to grow more and more complex during the past decade.

As opportunities for flights have decreased, people have tended to hang more and more features on each precious mission as it came along. This has increased costs and decreased further the number of missions that can fit under a budget envelope, further reinforcing the temptation to increase the scope of each mission.

Unfortunately, this syndrome has also affected the Explorers, a program originally meant to provide us with a flexible, inexpensive means of getting into orbit with minimal delays. It is time to reverse this trend. If not, the impact on university and other groups that depend on flight missions for their existence will be great. This increase in the level of funding Explorers will allow us to design missions in a realistic price range, so that the average frequency of the order of one flight per year can be achieved.

The decision to request a new start for the Venus Radar Mapper Mission, VRM, is most gratifying. The Committee on Planetary and Lunar Exploration of the Board has identified the high resolution mapping of the surface of Venus as the objective of the highest scientific priority for the study of that planet.

The Agency and the Jet Propulsion Laboratory are to be complimented for designing an imaginative, fresh approach to the problem of mapping Venus. With the spatial resolution promised by VRM, we should be able to identify important surface tectonic features, such as shield volcanoes, that will give us important clues to the structure of the interior of Venus and the evolution of the planet.

We should also be able to detect marine or surface water features, such as fossil river channels and seashores, if they exist, that will tell us something about the size of an ocean that may have covered Venus when it was a young planet and lead us to deeper insights into the origin and history of its atmosphere.

While I am on the subject of planetary exploration, I must mention one weakness in the program outlined by the Office of Space Science and Applications. This is the level of support requested for research and analysis for planetary exploration. The amount requested is below the level appropriated by the Congress for 1983.

And here I must take the opportunity warmly to commend the Congress for correcting an alarming cut in funding projected for planetary exploration and for physics and astronomy last year. The action that you took then preserved these fields so that they can be exploited by missions like the Venus Radar Mapper mission that are starting this year.

The amount requested for fiscal year 1984 is not sufficient to keep in existence research groups that will be needed to analyze the results NASA hopes to obtain in future planetary missions. I have not carried out the detailed analysis needed to state just how great the shortfall is. As a reasonable guide, I would suggest, as we suggested during this committee's hearings last year, that the level of support in fiscal year 1981 adjusted for inflation, would be adequate to maintain the R&A program in planetary exploration for the near term.

The prospects for the future in the NASA planetary program are certainly enhanced by the promulgation of the long-awaited report by the Solar System Exploration Committee of the NASA Advisory Council, chaired first by Dr. John Nagle and then by Dr. Noel Hinners. What that committee has done is to identify a new and affordable way for NASA to conduct missions to the planets that can be carried out by variations on existing Earth orbital spacecraft and by the new JPL series called Mariner Mark II spacecraft.

I think that it is important to put the first type of mission on the same stable, relatively low cost basis as the Explorer satellites. Instituting a level of effort program will allow us to get out of the mode in which every planetary mission becomes an all-out effort of the Voyager or the Galileo class.

Let me turn now to a less positive development. We are all very concerned about the delays that have developed in the Space Telescope production schedule. The board has been thoroughly briefed by NASA concerning this problem. We are watching carefully.

Our concern is to minimize the damage that may be done to the overall space science program as a result of the additional cost resulting from delay in completion and launch of the Space Telescope. ST problems should not be allowed to upset the balance in space science activity.

As in the case of planetary exploration, but to a lesser degree, there seems to be the same kind of failure to build on the base Congress provide in fiscal year 1983 for the research and analysis program in physics and astronomy.

Mr. Chairman, the Office of Technology Assessment last September published a very useful technical memorandum entitled "Space Science Research in the United States." We agree with OTA's finding that there is a crisis in space science and that its cause is a lack of stability in the support of research groups that has resulted from the strong mission orientation of NASA's space science program and the present hiatus in mission starts and launches.

I am pleased to be able to tell you that NASA at the level of the Administrator himself also recognizes the serious and fundamental nature of this problem. On the initiative of NASA's chief scientist, Dr. Frank McDonald, a panel consisting of six representatives of the academic community and six representatives of the agency has been formed.

The panel met on March 1 and 2 to begin an intensive study assessing the nature of the problem in NASA-university relations and trying to find new ways of doing business that will lead to the desired stability in the Nation's space science program. We hope this effort will address the concerns raised in the OTA memorandum and also provide new and important initiatives to put before you in fiscal year 1985.

Mr. Chairman, this concludes my prepared statement. I would certainly be happy to respond to your questions now and in writing after this hearing is concluded.

[The statement follows:]

STATEMENT OF THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL ACADEMY OF SCIENCES

FISCAL YEAR 1984 NASA BUDGET REQUEST

Mr. Chairman and Members of the Subcommittee: Thank you for giving me the opportunity to meet with you today to discuss the fiscal year 1984 NASA budget request and how it affects the space sciences. On behalf of the Space Science Board, I am pleased to be able to report that on the whole we are gratified by the level of support for space science expressed in the proposed budget.

From a comparison of the fiscal year 1984 budget request with trends in previous fiscal year budgets and culminating with the fiscal year 1984 budget request, there is evidence that an important shift has taken place in the Administration's assessment of the importance of the space science program. Unlike the situation in fiscal year 1983, there is balance among the major space science disciplines in the program; none are threatened with cancellation or eventual demise; major, ongoing development projects are funded adequately; a new start for the planetary program is requested (the contrast with the fiscal year 1983 request for the planetary program needs no emphasis from me); major study efforts to develop the queue for new start candidates are supported.

I sincerely hope that what we are seeing is the emergence of a period of stability in both a fiscal and programmatic sense. If that is the case, and it will take several years to confirm, we will finally have reached a point where together we can quietly assess the state of this national resource and lay the groundwork for its secure future. I shall address the question of support for the baseline programs for research and analysis and for mission operations and data analysis for on-going missions separately, for we have a continuing problem in some of these areas.

To say that the space science community is satisfied with this fiscal year 1984 budget request is an over-simplification and not altogether accurate, given what has happened to the field over the last half-dozen years. The economic imperatives that have constrained the level of overall activity and threatened some of the fields represented in space science have forced a serious discussion of the value to the nation of doing science in space and raised the question of whether there existed a level at which the future of the field could not be reasonably assured or might not be worth maintaining. I trust that the debate is ended with this budget submission. I hope this committee and the Congress will see the budget in this same light so that we can begin the task of reconstituting and rebuilding the U.S. position in space science.

My assessment of the NASA fiscal year 1984 budget request is reinforced by statements that have been made recently by Dr. George Keyworth, Science Advisor to the President. Writing in the February 18 issue of Science magazine, Dr. Keyworth includes space science among the fields selected for special emphasis in federal R&D program in fiscal year 1984 as likely to have the greatest long-term impacts on new technologies. I do not underestimate the challenge that has been posed by the Administration in the selection of space sciences for this task. We are being asked to address a major national concern: revitalization and mobilization of the science and technology base of the United States, not only to reassume our former positions of world leadership in selected areas of science and technology but also to lead the United States toward economic recovery and growth. It is a sobering responsibility, however, one that I believe we are eminently qualified to assume. And I would be remiss if I did not point out that it is a shared responsibility, that it is an undertaking that will need very careful strategic and tactical planning and, as importantly, a sustained long-term commitment by the Administration, the Congress, United States industry, and the space science community represented in United States universities.

Let me now turn to some comments on the details of the fiscal year 1984 budget request. The request for an augmentation in the Explorer line item is in accordance with long standing recommendations of the Space Science Board and its Committees on Space Astronomy and Astrophysics and Solar and Space Physics as well as those of the Astronomy Survey Committee chaired by Professor George Field. Probably the most important effect of this augmentation will be to allow the agency to increase the frequency of flight opportunities in the Explorer program. If Space Science is suffering a malaise these days—as it is—this state is a consequence of a dramatic decrease in the rate at which space science missions have been launched during the past decade and are presently scheduled for launch. The delays associated with changing from expendable launch vehicles to those of the space transportation system are partly responsible for the retardation. Associated with the decrease in the rate of flight opportunities has also been a tendency for missions to grow more and more complex during the past decade. As opportunities for flight have decreased, people have tended to hang more and more features on each precious mission as it becomes available. This has increased cost and decreased further the number of missions that can fit under a budget envelope further reinforcing the temptation to increase the scope of each mission. Unfortunately, this syndrome has also affected the Explorers, a program originally meant to provide us with a flexible, inexpensive means of getting into orbit with minimal delays. It is time to reverse this trend. If not, the impact on university and other groups that depend on flight missions for their existence will be great. This increase in the level of funding Explorers will allow us to design missions in a realistic price range so that an average frequency of the order of one flight per year can be achieved.

The decision to request a new start for the Venus Radar Mapper Mission (VRM) is most gratifying. The Committee on Planetary and Lunar Exploration (Complex) of the Board has identified the high resolution mapping of the surface of Venus as the objective of the highest scientific priority for the study of that planet. The agency and the Jet Propulsion Laboratory are to be complimented for designing an imaginative, fresh approach to the problem of mapping Venus. With the spatial resolution promised by VRM we should be able to identify important surface tectonic features (such as shield volcanoes) that will give us important clues to the structure of the interior of Venus and the evolution of the planet. We should also be able to detect marine or surface water features (such as fossil river channels and seashores), if they exist, that will tell us something about the size of an ocean that may have covered Venus when it was a young planet and lead us to deeper insights into the origin and history of its atmosphere.

While I am on the subject of planetary exploration, I must mention one weakness in the program outlined by the Office of Space Science and Applications—this is the level of support requested for research and analysis for planetary exploration. The amount requested is below the level appropriated by the Congress for 1983. (And here I must take the opportunity warmly to commend the Congress for correcting an alarming cut in funding projected for planetary exploration and for physics and astronomy last year). The amount requested for fiscal year 1984 is not sufficient to keep in existence research groups that will be needed to analyze the results NASA hopes to obtain in future planetary missions. I have not carried out the detailed analysis needed to state just how great the shortfall is. As a reasonable guide, I would suggest, as we suggested during this committee's hearings last year, that the level of support in fiscal year 1981, adjusted for inflation, would be adequate to maintain the R&A program in planetary exploration for the near term.

The prospects for the future in the NASA planetary program are certainly enhanced by the promulgation of the long awaited report by the Solar System Exploration Committee (SSEC) of the NASA Advisory Council chaired first by Dr. John Naugle and then by Dr. Noel Hinners. What that Committee has done is to identify a new and affordable way for NASA to conduct missions to the planets that can be carried out by variations on existing Earth orbital spacecraft and by the new JPL series called Mariner Mark II spacecraft. I think that it is important to put the first type of mission on the same stable, relatively low cost basis as the Explorer satellites. Instituting a level of effort program will allow us to get out of the mode in which every planetary mission becomes an all out effort of the Voyager or Galileo class. The missions identified by SSEC, such as the Mars Geoscience-Climatology Orbiter and the Comet Rendezvous Mission, all conform with the strategy for planetary exploration developed by the Board's Committee on Planetary and Lunar Exploration. Indeed SSEC carefully used Complex reports as a guide and interacted carefully with Complex during its work.

Let me turn now to a less positive development. We are all very concerned about the delays that have developed in the Space Telescope (ST) production schedule. The Board has been thoroughly briefed by NASA concerning this problem. We are watching carefully. Our Concern is to minimize the damage that may be done to the overall space science program as a result of the additional cost resulting from delay in completion and launch of the Space Telescope. It is important that the Space Telescope, when it is finally flown, be an instrument capable of performing up to the expectations we all have for it. Given the forced relaxation in the telescope delivery schedule there is an opportunity to do more thorough testing and to perfect some of the telescope instruments. This in abstract is a good and desirable thing to do, but it will cost money—and exactly the same judgement applies to other NASA missions that are suffering delays, specifically Galileo. So we have to be careful about what we recommend—to be even handed and, as I have said, to consider the ST problem in the context of the entire OSSA program. ST problems should not be allowed to upset the balance in space science activity.

As in the case of Planetary Exploration, but to a lesser degree, there seems to be the same kind of failure to build on the base Congress provided in fiscal year 1983 for the Research and Analysis program in Physics and Astronomy.

The Office of Technology Assessment last September published a very useful technical memorandum entitled "Space Science Research in the United States." We agree with OTA's finding that there is a crisis in Space Science, and that its cause is a lack of stability in the support of research groups that has resulted from the strong mission orientation of NASA's Space Science Program and the present hiatus in mission starts and launches. I am pleased to be able to tell you that NASA at the level of the Administrator himself also recognizes the serious and fundamental nature of this problem. On the initiative of NASA's new Chief Scientist, Dr. Frank McDonald, a panel consisting of six representatives of the academic community and six representatives of the agency has been formed. The panel met on March 1st and 2nd to begin an intensive study, assessing the nature of the problem in NASA/University relations and trying to find new ways of doing business that will lead to the desired stability in the nation's Space Science program. The Space Science Board will cooperate in this study. It will receive the report of the panel and provide to NASA an assessment of its recommendations. We hope that this effort will address the concerns raised in the OTA memorandum and also provide new and important initiatives to put before you in fiscal year 1985.

I would like to express our great satisfaction that NASA has filled the position of Chief Scientist and that it has selected a person from its own family. Dr. McDonald possesses excellent scientific and personal credentials. Those of us who have interacted with him since his appointment in September have been very impressed with the incisive and insightful way in which he has been helping the Administrator and the Associate Administrator for Space Science and Applications to formulate the science policy that guides NASA science programs.

Mr. Chairman, this concludes my prepared statement. I shall be happy to respond to your questions now and in writing later after this hearing is concluded.

Senator TRIBLE. Thank you, Dr. Donahue.

Let me ask you a question, if I might. The HEAO-2 data analysis program has been a very productive one for university experimenters and guest observers. The current estimate for that program in fiscal year 1983 is approximately $3.7 million. Under the fiscal year 1984 NASA budget request, the program will receive approximately $2.7 million to $2.8 million.

What in your judgment would be the consequences in this area of astrophysics if the reduced level of funding is maintained?

Dr. DONAHUE. I think it would be very unfortunate to maintain that level of funding. As you know, the Congress augmented the budget request of NASA last year for data and analysis of the HEAO-2 mission and brought the level of funding up to roughly the fiscal year 1982 appropriation level. This year the agency has come back to you with a 17-percent cut in proposed funding for this data analysis, which just takes away the augmentation that you saw fit to give us last year.

The reasons for the augmentation are as valid this year as they were last year. This mission is the—it has produced a wealth of exciting data concerning the universe. There is no prospect of further high-energy astronomical observations until the next decade, with the possible launch of the advanced X-ray astronomical facility, AXAF. So it is vitally important that we analyze the data that we obtain from this mission.

This is a continuing problem, I am unhappy to say, with NASA. That is, the tendency to obtain data from missions and then underfund the analysis of the data. It is not a very sane kind of policy, it seems to me, to spend so much to accumulate the data and then not analyze them after they have been obtained.

Senator TRIBLE. Dr. Shapley, I have a question here from Senator Hollings. He asks that this question be asked for the record here today. So let me read this question, if I might, and then I would invite your response:

> Dr. Shapley, your statement on behalf of the space Applications Board is to the point and excellent. I am concerned the space applications portion of the NASA budget is both most important for this country's economic and technological leadership and the most underfunded of the space programs in the 1984 budget.

Senator Hollings goes on:

> Let me cite a few figues relating to those space applications activities of commercial and economic significance. In remote sensing, OMB provided NASA with $46.4 million; in materials processing, OMB provided $21.6 million; in communications, OMB provided $21.1 million; and for technology utilization, only $4 million. This totals $93 million for commercially significant space applications programs. In percentage terms this represents just 8.6 percent of the NASA science and applications program and only 1.3 percent of NASA's overall budget.
>
> Dr. Shapley, I am sure you share my concern over these figures, and I am just wondering if you could shed some light as to why it is that OMB has so underfunded these critical important applications programs.

Dr. SHAPLEY. Thank you and Senator Hollings both.

As you may note from my bio sheet, Mr. Chairman, I have worked for 23 years in the Bureau of the Budget, which is what OMB was then. So I have some appreciation of their problems and the very difficult tasks that they face with the size of the deficit we have and everything else. So I think I can understand that.

On the other hand, I am not the person to answer why they did this, that or something else. I should comment that one of the inherent problems that has plagued the NASA space applications program almost from the beginning has been the difficulty in distinguishing between what the Government should do in promoting civil space applications and what the private sector should do.

Earlier today we had testimony on that matter relating to the aeronautics area. It is very encouraging to me—and I am sure to the space Applications Board—that the administration during this past year came to a new policy declaration in the aeronautics field where they explicitly recognized the legitimacy of activity on both the Government's part, as well on industry's.

In the space applications area, including all the ones that the Senator mentioned in his question, a similarly clear delineation has really never been made. And what has happened is that each time a proposal comes forward, either out of NASA or out of the interested civil community, on what NASA might do in space applications, the question always comes up: If it is worth doing, shouldn't private enterprise put up the money and do it themselves?

I think the conclusion that we have all learned over 15 or almost 20 years of this kind of dialog is that there has to be a partnership on the long-range, high-risk technology areas. There is a legitimate role for the Government, no matter what your ideological outlook may be on the role of the Government generally.

As the gentlemen testified this morning, earlier this morning on aeronautics, there are the long-range, high-risk areas—those are the ones in which it is not reasonable to expect a single company to put up the money to do research and experimentation that is going to benefit all companies. And so you have to have a division in which the high-risk work is sponsored by the Government, and if you can work out any private participation in the financing, so much the better.

But to exclude or to always attempt to minimize Government financing as the primary objective, which unfortunately frequently has to be the objective in making that Government budget, this has the very unfortunate effect that we are not able to move along as fast as we can and we have a situation which disappoints, I believe, most of us.

Senator TRIBLE. Let me ask you a further question, if I might, on my own. The fiscal year 1984 NASA request contains $15 million for continued operation of the Landsat Thematic Mapper data processing system and for the engineering characterization of TM data. There is also $15 million for Earth remote sensing instruments, the multispectral linear array, and the large format camera, the former to be launched aboard the Shuttle.

What else should NASA do in your judgment to advance the technology of a land remote sensing satellite system and insure a fluid transition of that land remote sensing system to the private sector, should that transfer occur?

Dr. SHAPLEY. That is a difficult question, Mr. Chairman. In the first place, I would say that it is very important that the type of advanced research and technology in remote sensing that you mentioned, be permitted to continue, and that it be funded at a level which really permits progress to be made.

The tougher question is how do we go about providing the next improved or continuation of the satellite systems up in space? And this is tied up very directly, as I mentioned in my statement, with the question of whether there is to be commercialization and, if so, on what terms.

It is also complicated by the fact that by agreement now within the executive branch this responsibility is really no longer NASA's.

This really belongs to NOAA and the Department of Commerce to make this decision, and it is their responsibility to take the initiative and see that what needs to be done gets done.

So as far as NASA is concerned, I would hope that the budget for NASA would provide adequate well-rounded support for the research and technology that is needed, and that Congress would focus on the NOAA and commercial side of it to see that the right decisions are made in maintaining the satellite systems.

Senator **Trible**. In your judgment, does the budget submission provide adequate funding in this area at this time?

Dr. **Shapley**. No. I think it is tighter than it ought to be.

Senator **Trible**. Would you care to advance an idea of how it should be expanded?

Dr. **Shapley**. Let me look at that again and provide something for the record if I may.

[The material referred to follows:]

In my opinion, $10 million could usefully be added to NASA's fiscal year 1984 budget request for research and technology work in land remote sensing. The development of techniques for the analysis of thematic mapper (TM) data is an example of an important area where additional funding is badly needed. The funds added should be in the form of "new" money, not derived by transfer from other parts of the NASA budget, which is already overly "tight".

Senator **Trible**. Good, if you would do that. And I have a number of other questions that I would like to submit to each of you, if you would be so kind to provide answers for the record.

I thank you for your presence here today and for the contribution you made to these proceedings.

With that, I think that is the last of our witnesses today, so this meeting is adjourned.

[Whereupon, at 11:20 a.m., the subcommittee was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

The Aerospace Industries Association of America, Inc., (AIA), representing the nation's major manufacturers of military, commercial and business aircraft, aircraft engines and helicopters and their related components and equipment, appreciates the opportunity to provide our comments for the record of the Subcommittee's recent hearing on NASA's '84 aeronautics budget.

The panel of airframe and engine manufacturers—both civil and military—which appeared before the Subcommittee on March 15, reaffirmed industry's endorsement of the Office of Science and Technology Policy's (OSTP) 1982 report on aeronautical research and technology (R&T). Many of the conclusions reached by the OSTP supported a point that our industry has been emphasizing for a number of years: That the aerospace industry is a vital industry, continually refining and incorporating evolving aeronautical technology into superior products which will guarantee the industry's continued ability to contribute to the U.S. economy—in terms of job creation, balance of trade enhancement through export sales, generation of tax revenues, and the maintenance and strengthening of our national defense.

Of the cited benefits flowing from a strong aerospace industry, we would like to emphasize the importance of our sector as the nation's pre-eminent manufacturing exporter and contributor to the net U.S. balance of trade. This role is of particular relevance as the 98th Congress addresses the jobs issue, in view of the strong correlation between employment and export activity. Last year, AIA requested Chase Econometrics/Interactive Data Corporation to perform an independent study on the effect of aircraft exports on the U.S. economy. The study, attached for your review, was designed to conservatively evaluate the effect of an increase in exports through direct benefits, multiplier effects, government budget considerations and follow-on sales for spare parts and fleet expansion.

Using as a baseline case the Chase Long-Term, Moderate Growth Scenario of 1981, the study showed that $1 billion in initial aircraft sales and resulting follow-on sales would generate an additional $6.5 billion (1982) in GNP during the period from 1982-90. Of this, almost half ($3 billion) reflects increased consumption resulting from the incremental direct and indirect wage earnings. Investment would increase to $1 billion, with the remainder of the $6.5 billion increase generated by a $2.4 billion increase in net exports. The increase of $1 billion in initial aircraft exports would, importantly, add 44,000 full time equivalent (FTE) man-years employment in the aerospace industry. Through subcontracting and the multiplier effects mentioned above, this would lead to a total increase of 148,000 FTE man-years in the U.S. economy from 1982-90.

This increase in aircraft exports—and associated job creation—impacts government receipts and expenditure through personal and corporate income taxes, social security receipts, state and local receipts, unemployment compensation payments and government interest expenses. The total reduction in the federal deficit (including interest expense impacts) over the period is $3.7 billion in current dollars, or $2.4 billion in 1982 dollars.

Because of the high technology and large scale nature of aerospace production and its importance to national defense, the export of aerospace products provides several other key benefits to the national economy. While these benefits are admittedly difficult to quantify, they are nonetheless curcial to the United States. One such export-associated national asset is the maintenance of a large and well-trained, high technology labor force. These workers simultaneously produce the "big ticket" items which aid the U.S. balance of trade accounts and provide an in-place, non-government funded wartime mobilization capability. Reductions in this existing pool of skilled labor—due to either falling export or falling domestic sales—will reduce the U.S. capability in emergency situations. Similarly, existence of civilian facilities for aerospace research and production also add to the U.S. defense emergency surge capability. When such facilities can serve both civilian and military requirements, the DOD burden of maintaining dedicated facilities is reduced, either directly or through contracts—in turn reducing the overall cost of defense systems.

Foreign market demand for U.S. aerospace products also offers our domestic manufacturers the opportunity to sell a greater number of units. Thus, fixed production costs—e.g., facilities, equipment and land—can be spread over a larger number of aircraft, engines or missiles, substantially reducing the cost of each unit, and the price paid by domestic customers. The existence of foreign markets is also crucial to the aerospace industry, because of the magnitude of investment required and the low profit margin. Export sales also contribute part of the funding for each new aircraft generation's R&D requirements, which advance the state-of-the-art in aerodynamics, communications and electronics. These new technical advances often find application in a variety of areas other than that for which they were originally designed—there is a sharing of knowledge between the civil and military sectors of the aerospace industry (crossover) and a transfer of the technology and know-how, originally developed for aerospace, to other domestic industries (spinoff).

The OSTP report recognized the extent of this civil-military crossover, and rejected any attempt to establish separate research efforts. Significantly, the technology spillover which once ran in a military-civil direction has now begun to flow largely in the opposite direction. The KC-10 tanker, the AWACS and the Advanced Airborne Command Post were based on the privately funded McDonnell Douglas DC-10 and Boeing 767 and 747 aircraft programs, respectively. In addition to this crossover of essentially complete aircraft, there is an increasing transfer from civil to military of information on materials and subsystems. This civil to military crossover saves the services, and ultimately the taxpayers, large annual sums of money, while assuring the military's access to ever-increasing technological advancement.

From the industry's perspective, the key recommendation in the OSTP report concerns continued government support for aeronautical R&T development and military aeronautical technology demonstration. As the industry witnesses stated during the March 15 hearing, we have long believed that such government investment is justified as the benefits resulting from aeronautical R&T advancement are paid out to the country as a whole. Without that level of support, which does not begin to approach the more extensive government participation which so many of our foreign competitors enjoy, the U.S. aerospace industry will find itself increasingly constrained in its efforts to strive for and maintain a technological edge—the ultimate selling point for our products.

The American aerospace industry has not lost the willingness nor the capability to shoulder the responsibilities associated with the development of high technology, advanced new concepts and products which will continue to assure our competitiveness in the world market. But we have had to come to terms with the economic reality of pursuing increasingly advanced technologies, and this reality has become more brutal in the wake of a global recession. Taking a proposed aircraft from concept to completion is a costly and time-consuming endeavor. Development of a new commercial aircraft or engine runs into billions of dollars, often exceeding the net worth of a company. With this large an investment at stake, a company will find it necessary to employ technologies involving modest risk—even to the point of foregoing riskier technologies with potentially greater benefits.

Government support in the pre-application phases—i.e., basic research and technology evolution—is necessary because industry alone cannot support all the promising areas of R&T. It must concentrate its resources on projects which are clearly feasible and which offer reasonable assurance of near-term payoff. It is essential, therefore, that government conduct research in those areas where the risk is too great, the potential payoff too distant, and the market uncertain. NASA's tradition of supplying proof-of-concept technology has stimulated and aided the industry in assessing subsequent development risks; once this proof-of-concept information is available, industry must then invest more than ten times as much of its own money to develop and then market worldwide the resulting new products incorporating the new technology. Ultimately, the sales of these new products—with the attendant benefits that flow to the national economy as a whole—could exceed NASA's original investment one hundred times over.

Surveys conducted last year indicated that 60 percent of total aerospace sales during the 1982-90 time frame will be made to customers outside the United States Capturing a significant portion of that projected market will depend upon our ability to enhance the competitiveness of our products by incorporating the latest technology. And we are guaranteed of a run for our money in our attempts to do so—our foreign competitors have no less an appreciation of the benefits of export trade, and they have not been reluctant to target certain industries, notably aerospace, for increased R&D investment and capitalization. Conversely, U.S. investment in aeronautical R&D as a percentage of sales has been dropping steadily during the last decade.

If we are to retain and expand the number of transport-manufacturing jobs and other national benefits associated with the role of world leaders in aeronautics, we must reaffirm the industry/NASA relationship, and the Congress must take a role in assuring that the OSTP recommendations are implemented. This will require that Congress move beyond endorsement of those recommendations to a steady, long-term commitment of support and funding for NASA's aeronautical R&T programs.

Attachment.

THE BENEFITS OF EXPORTS TO THE NATIONAL ECONOMY—A CASE STUDY FROM THE U.S. AIRCRAFT INDUSTRY

(Aerospace Research Center, Virginia C. Lopez, Director; Celia M. Sherbeck, Economist)

A CASE STUDY [1]

Methodology

In order to get an independent evaluation of the impacts on the U.S. economy of a change in aircraft exports, the Aerospace Industries Association asked Chase Econometrics/Interactive Data Corporation (Chase) to examine these effects.

Chase used its Macroeconomic and Interindustry Models to examine the impact of a $1 billion increase in 1982 aircraft exports. Due to the long lead times in aircraft production it is assumed that enough sales have been made to cause a $1 billion increase of deliveries to export markets in 1982. Baseline for comparison was the Chase Long-Term Moderate Growth Scenario of November 1981. All monetary figures represent 1982 dollars unless otherwise stated. Direct and indirect effects were examined for the period 1982-1990.

Assumptions

Several key assumptions made in the study must be noted. First, since the $1 billion increase in aircraft exports is small relative to the three trillion dollar U.S. Economy, it was assumed that the increase would have no significant impact on the general price level in the United States. Further, it was assumed that the increase in aircraft exports would have no effect on the magnitude of federal, state and local government expenditures for goods and services.

TABLE 10.—*Export assumption—Annual value of aircraft and parts sales, 1982-90*

1982	1.00
1983	.18
1984	.26
1985	.34
1986	.35
1987	.35
1988	.35
1989	.28
1990	.20
Total	3.32

Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corp., for the AIA, June 1982.

NOTE: Components may not add to totals due to rounding.

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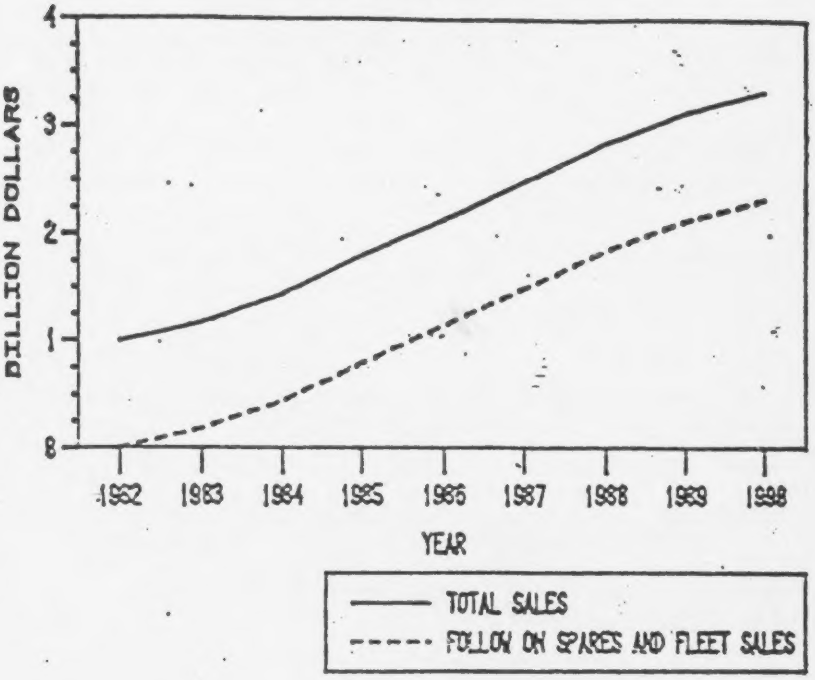
[1] From a report on "The Economic Impacts of Increased Aircraft Exports," prepared by Chase Econometrics/Interactive Data Corporation for the Aerospace Industries Association, June 1982.

FIGURE 6

Cumulative Sales Increase In Aircraft Exports



Source:--"The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corporation, for the AIA, June 1982.

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In keeping with the pattern of follow-on sales experienced in the market for aircraft, aircraft engines and spare parts, it was assumed that the initial increase of $1 billion would lead to increases in export sales for spare parts and follow-on fleet sales. In addition to the initial sales, incremental exports of 1 percent per year for spare parts were assumed for each year—1983 through 1990.

Further, it was assumed that increased follow-on fleet sales would amount to three times the value of the initial sale over a 20-year period with 75 percent of those sales falling during the 1983 to 1990 time period. This amounts to increased follow-on fleet sales of $2.24 billion.

Table 10 shows the annual value of the additional aircraft exports assumed. Figure 6 depicts the cumulative effect.

TABLE II.—INDUSTRY EMPLOYMENT GAINS

	Full-time equivalent (FTE) job-years		Percent of total industry employment
	Total 1982–90	Annual average	
Total employment	148.40	16.49	0.02
Major industry impacts:			
Transportation equipment	46.25	5.14	.29
Aerospace	44.20	4.91	.90
Other	2.05	.23	.02
Finance and services	22.75	2.53	.01
Trade	21.87	2.43	.01
Construction	17.84	1.98	.03
Nonelectrical machinery	5.46	.61	.02
Electrical machinery	5.04	.56	.02
Transportation services	4.70	.52	.01
Fabricated metals	4.13	.46	.03
Instruments	3.03	.34	.05
Primary metals	2.88	.32	.02
Food and beverages	2.28	.25	.01
Publishing	1.92	.21	.02
Communication services	1.65	.18	.01
Chemicals	1.58	.17	.01
Rubber and plastics	1.24	.14	.02
Agriculture	1.18	.13	.02
Stone, clay, and glass	.94	.10	.02
Paper and pulp	.92	.10	.01
Textiles	.65	.07	(1)
Furniture	.59	.07	.01
Lumber	.56	.06	.01
Public utilities	.40	.04	(1)
Mining	.30	.03	(1)

(1) Less than .01 percent.

Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corp., for the AIA, June 1982.

TABLE 12.—INDUSTRY OUTPUT GAINS

[In millions of 1982 dollars]

	Shipments		Percent of total industry output
	Total 1982–90	Annual average	
Total output	10,655	1,183	0.03
Major industry impacts:			
Transportation equipment	5,457.9	606.4	0.20
Aerospace	5,066.4	569.0	0.55
Other	391.5	37.4	0.03
Trade	1,096.4	121.8	0.01
Finance and services	513.4	57.0	(1)
Primary metals	501.5	55.7	0.02

TABLE 12.—INDUSTRY OUTPUT GAINS—Continued

[In millions of 1982 dollars]

	Shipments		Percent of total industry output
	Total 1982–90	Annual average	
Electrical machinery	458.0	51.0	0.02
Transportation services	385.9	42.9	0.02
Nonelectrical machinery	382.9	42.5	0.01
Fabricated metals	358.1	39.8	0.02
Construction	308.7	34.3	0.02
Food and beverages	231.5	25.7	0.01
Public utilities	218.4	24.3	0.01
Instruments	151.3	16.8	0.03
Petroleum refining	148.9	16.5	(1)
Communication services	144.2	16.0	0.01
Chemicals	134.1	14.9	0.01
Stone, clay, glass	101.8	11.3	0.01
Agriculture	96.2	10.7	(1)
Publishing	75.1	8.3	.01
Paper and pulp	67.5	7.5	.01
Rubber and plastics	65.5	7.3	.01
Lumber	26.3	2.9	(1)
Furniture	25.9	2.9	.01

[1] Less than 0.01 percent.

Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corp., for the AIA, June 1982.

TABLE 13. IMPACT ON REAL ECONOMIC ACTIVITY

	1982	Total
GNP	1.20	6.50
Consumption	.29	3.01
Durables	.14	.63
Nondurables	.10	.85
Services	.05	1.53
Investment	.06	1.07
Nonresidential structures	.02	.46
Nonresidential equipment	.01	.25
Residential	.00	.12
Inventory change	.03	.24
Net exports	.85	2.42
Exports	1.00	3.27
Imports	.15	.85

Note: Components may not add to totals due to rounding.

Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corp., for the AIA, June 1982.

Using these follow-on fleet assumptions is tantamount to assuming an increase of $1 billion in export sales of a new generation of aircraft or sales of an older model to a new customer. An example of this might be the sale of 12 767's and 16 757's to new customers, or the additional sale of 10 to 16 747's, or 15 DC10–30's.

Results

Using the assumptions and methodology described above, Chase found that an initial increase of $1 billion in aircraft-related exports would add 44,000 full time equivalent (FTE) man-years in the aerospace industry. As a result of supplier sales and the multiplier effects describer earlier, the total impact of the $1 billion increase would be 148,000 FTE man-years during the period 1982–90. Table 11 shows the division of these man-years into various industries. Both the total impact and the average annual impact are presented.

Total gross industry output, which includes both intermediate and final sales, follows a pattern of impacts similar to that seen in employment. Table 12 depicts the distribution of the $10 billion total impact by industry.

The initial $1 billion generates a $6.5 billion increase in GNP over the period 1982-90. Almost half ($3 billion) of this reflects increased consumption resulting from the incremental direct and indirect wage earnings. Investment increases $1 billion over the baseline case. The remainder of the $6.5 billion GNP increase is due to a $2.4 billion increase in net exports. The initial increase leads to a total gain in exports of $3.3 billion and the nearly $0.9 billion increase in imports reflects the use of foreign-made aircraft components and other unrelated goods, such as those for individual consumption.

Table 13 shows the 1982 and total 1982-90 impact of aircraft exports on the U.S. GNP. As described above, such an increase in exports also has an impact on government receipts and expenditures through personal and corporate income taxes, social security receipts, state and local receipts, unemployment compensation payments and government interest expense. The 1982 impact on government budgets, excluding interest expense, is $400 million.

As shown in Table 14, the cumulative effect on government funds and spending for the nine-year period amounts to 2.7 billion current dollars or 2.05 billion in 1982 dollars. These figures include the impact on tax receipts and unemployment compensation. When the additional impact on government interest expenses are added to this, the total impact on the Federal Deficit is $3.7 billion (current $) or $2.4 billion (constant 1982 $).

TABLE 14.—IMPACT ON GOVERNMENT RECEIPTS AND EXPENDITURES

[In billions of dollars]

	Current dollars		Constant dollars	
	1982	Total 1982-90	1982	Total 1982-90
Federal receipts	0.31	2.17	0.31	1.64
Personal income taxes	.11	.77	.11	.58
Corporate taxes	.08	.50	.08	.40
Social security receipts	.12	.90	.12	.67
State and local receipts	.04	.23	.04	.18
Unemployment compensation	—.05	—.03	—.05	—.24
Total impacts on Government funds and spending	.40	2.70	.40	2.05

Note: Components may not add to totals due to rounding.

Source: "The Economic Impacts of Increased Aircraft Exports" prepared by Chase Econometrics/Interactive Data Corp., for the AIA, June 1982.

STATEMENT OF DR. S. M. KRIMIGIS, CHIEF SCIENTIST, SPACE DEPARTMENT, APPLIED PHYSICS LABORATORY, JOHNS HOPKINS UNIVERSITY ON BEHALF OF THE SPACE SCIENCE WORKING GROUP, ASSOCIATION OF AMERICAN UNIVERSITIES

Senator Gorton and Members of the Subcommittee, I submit this statement to the subcommittee on behalf of the Space Science Working Group, a consortium of research universities which participate in NASA-sponsored space science programs.

Let me begin by stating how we at the universities view the objectives of the U.S. Space Science and Exploration activity. The Space Science program

(a) Addresses scientific questions of the highest intellectual significance.
(b) Provides practical information about our own planet Earth.
(c) Stimulates the development of new technology.
(d) Brings worldwide recognition to the U.S. for its unchallenged leadership.
(e) Attracts young people to careers in science and engineering.
(f) Manifests a policy of cooperation with other nations.
(g) Is viewed with pride and satisfaction by the U.S. public.

Despite these positive attributes, federal support of space science and exploration has declined to dangerously low levels in the past half dozen years. This decline has damaged space science in the universities, because there are no alternative ways to support the undergraduate students, graduate students, postdoctoral research associates, engineers and technicians who carry out space science projects under the direction of faculty members.

NASA and industry look to the universities for fundamental conceptual advances in space instrumentation and research required to make spectactular discoveries. Further, the universities serve as the training ground for future generations of scientists and engineers who contribute the discoveries, innovation and new ideas so essential to our technological leadership and economic well being. These scientists and engineers are employed not only in space-related activities, but mostly in industry and government where they contribute new concepts to solution of pressing technological problems. As an example, I recall the case of a recent graduate trained in space instrumentation who is currently working with a small company developing equipment for rapid measurement of sulfur content in coal, an essential tool in our efforts to clean our environment. Such innovations are essential to generating new jobs which are so important to our national economy today.

Last year, the U.S. Congress took positive action to stem the downward trend in space science and exploration. We are very grateful and encouraged by that action which augmented the proposed space science budget and, by doing so, prevented what would have been disastrous consequences for the space science research base in this country. In addition, we wish to commend this committee's actions in support of the Universities' participation in NASA's space science program.

We are also encouraged by the Administration's fiscal year 1984 federal research budget in general, and the NASA budget in particular, which promises the beginning of important progress toward revitalizing space science in the United States. This year, the President's Science Advisor has stressed the importance of federal support of basic research as a way to strengthen long-term industrial growth and national security. Dr. Keyworth has emphasized both knowledge and training as the important reasons for university-based research and has said that "America's universities are the core of our world leadership in science." We are pleased Mr. Chairman, to see political leaders of both parties espouse the view that research and development is the keystone to our economic viability, and indeed to our national survival as a modern industrial state.

I would like to comment on some very positive aspects of the NASA and space science budget for fiscal year 1984.

1. Funding for the Venus Radar Mapper, the first planetary new start in 5 years signifies NASA's commitment to a planetary program. This mission can be expected to have an important salutary effect on planetary space science in the universities.

2. There is a significant augmentation of the Explorer program which will provide an ongoing level of support of opportunities for small spaceflight experiments of the Principal Investigator class to be developed in universities and national laboratories.

3. Funding for the development of the Tethered Satellite system will provide a new Shuttle capability for conducting experiments in space in future years.

The funding of each of these projects as well as support for other ongoing missions and activities add up to a renewed commitment to a stronger national space program.

RECOMMENDATIONS OF THE SPACE SCIENCE WORKING GROUP

The Space Science Working Group has examined the proposed fiscal year 1984 NASA budget to determine its effect on space science, in particular the research carried out at universities. The budget lines which support university-based activities are Research and Analysis (R&A) and Mission Operations and Data Analysis (MO&DA). The adequate funding of these budget line items are critical to the conduct of basic research and scientific training and are relatively inexpensive to sustain in the context of the overall NASA budget.

To fulfill our commitment in strengthening research at the universities, i.e. fostering innovation, high technology, training of new talent, etc. we have identified some areas in the budget where a small augmentation is likely to result in significant scientific and technological advancements. We consider these augmentations to be critical to the vitality of space science at universities.

	Millions
Planetary exploration research and analysis	$11
Physics and astronomy research and analysis	4
Physics and astronomy mission operations and data analysis	1
Environmental observations—Space Physics ATD research and analysis	2
Total	18

This $18 million augmentation is for the various budget lines which directly support experimental and theoretical research at universities as well as conceptual and experimental developments that form the basis of new missions.

PLANETARY RESEARCH AND ANALYSIS—RECOMMENDED AUGMENTATION $11 MILLION

This augmentation is for the basic planetary research programs. This basic research is an important component of the NASA space science program and, in part, represents the means by which results of spacecraft investigations are turned into real knowledge and understanding. The administration's request is $4.8 million below the Congressional appropriation for fiscal year 1983. The recommended augmentation will forestall large additional reductions in the nation's basic planetary research programs in universities and national laboratories, and will allow very modest steps toward restoring these programs to a minimally acceptable level of vigor. It will also permit a very modest start of an Outer Planets Data Analysis program. The regular mission operations funds allow for the basic reduction of raw data to a usable form and for preliminary interpretation by the spacecraft teams. This Data Analysis program will permit general access to and use of the data by the wider scientific community. Data analysis programs of this type provide the means of exploiting and developing information gained through spacecraft investigations, and an important way to bring new young scientists into the scientific program.

PHYSICS AND ASTRONOMY RESEARCH AND ANALYSIS—RECOMMENDED AUGMENTATION $4 MILLION

This augmentation is recommended for basic research programs. A major portion of R&A funding directly supports experimental and theoretical research at universities which interpret and disseminate the scientific results from flight programs. Another major portion supports the conceptual and experimental developments that form the basis for new missions. The congressional action of adding $2 million to the President's fiscal year 1983 budget for this line item has provided much needed support for rejuvenation of this vital area of NASA's basic research base. The recommended augmentation would restore support to approximately the fiscal year 1981 level, which was already seriously constrained.

PHYSICS AND ASTRONOMY MISSION OPERATIONS AND DATA ANALYSIS—RECOMMENDED AUGMENTATION $1 MILLION

This augmentation is recommended to fund the analysis of data from NASA's HEAO-2/Einstein satellite at current levels. The fiscal year 1984 budget proposes a 17 percent cut in this productive scientific program. HEAO-2 ceased operations in mid-1981; however, the 2½ years of X-ray data it acquired will be the best available for most of the 1980's. The next major U.S. X-ray telescope—AXAF—will not be launched before 1990. Until then, the HEAO-2 funding represents a major source of support for scientists and students involved in X-ray astronomy at U.S. universities and research institutions.

ENVIRONMENTAL OBSERVATIONS SPACE PHYSICS/ATD RESEARCH AND ANALYSIS—RECOMMENDED AUGMENTATION $2 MILLION

This augmentation is recommended for the Advanced Technology Development (ATD) for the program Origin of Plasmas in the Earth's Neighborhood (OPEN). Although this line item has shown some nominal (3 percent) growth from fiscal year 1983 to fiscal year 1984, funding for the only effort in Advanced Technology Development, the OPEN program, has decreased from $3.5 million in fiscal year 1983 to a proposed $1.8 million in fiscal year 1984. The OPEN program represents the only major U.S. initiative in space plasma physics in this decade, with extensive involvement by University investigators in over 30 experiments. The proposed funding level of $1.8 million is insufficient to support these University teams in pursuit of further experiment definition activities. We deem it essential that these university teams continue to be supported.

ADDITONAL PROBLEM AREAS

In our opinion the $18 million augmentation to the fiscal year 1984 budget is crucial for space science at universities; however, there are additional problems confronting these areas of research to which we also call attention. The ultimate viability of university research programs in the space sciences requires that these problems also be addressed:

Planetary research and analysis—additional $8 million.—Restoring the planetary program to its already constricted fiscal year 1981 level of effort would require an augmentation to the proposed fiscal year 1984 budget of $19 million. The $11 million labeled as crucial above goes part way, but the remaining $8 million must ultimately be restored. We concur with the analysis of the Division of Planetary Sciences of the American Astronomical Society regarding these increments and endorse their recommendations.

Shuttle/spacelab payload development (physics and astronomy, and space plasma physics of environmental observations)—additional $6 million.—In response to an Announcement of Opportunity issued by NASA in 1978, about 300 proposals were recieved and 29 U.S. funded Principal Investigator (PI) class experiments were selected. Of these 29, only 3 have been funded for development and 13 more for definition studies, leaving 13 selected but not funded. With the successful completion of the Shuttle orbital test flight program, we urge that the potential afforded by Shuttle for useful science be realized by a more vigorous program of PI-class experiments. We urge NASA to study the Spacelab program and modify the ground rules for experiment implementation so that development of substantially more PI-class instruments can be carried out without significant increase in the budget. Effective university participation depends on reducing costs and simplifying procedures for PI experiments on Spacelab. At the same time additional funding of $6 million would permit further activity in definition and development of these selected investigations.

Suborbital programs—additonal $2 million.—An addition of $2 million to the sounding rocket program for Spartan development would permit significant advance in one realistic approach to the process of Shuttle experiment flight. The Spartan program takes payloads developed under the suborbital sounding rocket program, and uses Shuttle to place them in orbit and retrieve them two or three days later. As part of the fiscal year 1983 budget action in Congress last year, $1 million was added to the suborbital program and this addition is being applied to the sounding rocket program for Spartan. The fiscal year 1984 sounding rocket line in the President's budget seems to be based upon the fiscal year 1983 budget before this $1 million was added.

Laboratory equipment—recommended addition of $6 million to R&A.—We propose beginning a new program of upgrading laboratory capital equipment at universities. A decade of underfunding has resulted in a general obsolesence of the research equipment used in universities for basic studies aimed at development of concepts and instruments for future space science missions, and at analysis and interpretation of data from previous missions. This problem of NASA-funded research groups is part of a general problem in universities which has been addressed in recent statements by Dr. Keyworth. We consider it essential that NASA develop a new program of grants for acquisition of research equipment at universities and recommend an increment of $6 million specifically toward this end, with $3 million in the Physics and Astronomy R&A, $2 million in Planetary Exploration R&A, and $1 million in Space Physics R&A.

All of the items enumerated so far add up to a total of $40 million, which is only about 0.5 percent of the total NASA budget. Yet this relatively small amount provides high leverage in terms of technological innovation and scientific advancement. These funds would go a long way towards restoring a degree of relative health in space science activities at the nation's research universities.

Our detailed analysis of the space science budget and its development from fiscal year 1981 is given in Appendix A for your information and perusal.

I would also like to comment briefly on two other areas of the Subcommittee's concern:

(1) The OTA Technical Memorandum on space science. We are in general agreement with the general thrust of this memorandum, as far as it goes. The report emphasized the difficulties of planetary science, which appeared to be the most pressing issue at the time. However, the predicament of other branches of space science, including solar and magnetospheric physics and X-ray astronomy, is equally severe. The end result is that the United States is slowly dropping out of several fields of space science because of the interminable studies, delays, and eventual cancellation of several well-planned programs in the late seventies and early eighties. As a consequence, leadership in space sciences may well pass to other countries with a more determined approach, such as Germany, France, Japan and the U.S.S.R. A more detailed discussion of these issues, prepared by Professor E. N. Parker of the University of Chicago and reflecting the thinking of the SSWG, is appended to this statement as Appendix B.

(2) The SSWG is most favorable to the continued development of the Space Telescope and its proposed operation through the ST Science Institute. It is a good example of NASA's development of a facility whereby access is provided to the university community through competitive selection of focal point instrumentation and of guest observers.

Finally, Mr. Chairman and Members of the Subcommittee, let me say that, on behalf of the Space Science Working Group. I am most appreciative of the opportunity to present the concerns of the nation's leading research universities to this Subcommittee.

APPENDIX A

SPACE SCIENCE AT UNIVERSITIES IN THE FISCAL YEAR 1984 NASA BUDGET

INTRODUCTION

This report summarizes the effect on space science of the President's proposed fiscal year 1984 NASA budget. (See Table 1 attached) It emphasizes aspects of the budget of the Office of Space Science and Applications (OSSA) which fund research at universities.

The proposed budget includes two valuable new items, a new start for the Venus Radar Mapper and a significant augmentation in the Explorer budget. Both of these spaceflight programs are of great value to space science, and of special interest to university scientists.

At the same time the fiscal year 1984 budget continues a serious erosion of the science base support for research and analysis, particularly in the Planetary Exploration program, although the rate of erosion is not as drastic as was proposed a year ago in the President's fiscal year 1983 budget.

BACKGROUND

The lines of NASA's budget which provide the most research funding to universities are Research and Analysis (R&A) and Mission Operations and Data Analysis (MO&DA). There is an R&A line in each of the OSSA programs and an MO&DA or an Extended Mission Operation line in most of the programs. Funds for R&A support basic research programs from which many relatively inexpensive science results emerge and from which come the new concepts that are the foundation for future major spaceflight missions. The MO&DA line principally supports operation of spacecraft which are in orbit and analysis of data from operating and recently terminated spacecraft.

A year ago, the fiscal year 1982 operating plan and the President's proposed fiscal year 1983 budget contained drastic cuts compared to fiscal year 1981 in the Planetary program for both R&A and MO&DA, as well as significant but less drastic cuts in real support levels (after accounting for inflation) in Physics and Astronomy. Analysis by the Space Science Working Group showed that an additional $60 million ($40 million in Planetary Exploration and $20 million in Physics and Astronomy) was needed in the fiscal year 1983 budget to preserve the (already tight) fiscal year 1981 level of research effort. Action on the fiscal year 1983 budget by the Congress, adding $27 million to the Planetary budget and $5 million to Physics and Astronomy, significantly reduced the damaging effects of the proposed budget. The result has been that, while fiscal year 1983 sees a continued belt-tightening in which inflation is eroding the level of university research, the Planetary program has been saved from dismantling.

While the proposed fiscal year 1984 budget does not contain cuts as drastic as those which were proposed for fiscal year 1983, it still imposes a substantial decrease in support for R&A below fiscal year 1981 levels. The problem is especially evident in the Planetary R&A line, for which the proposed fiscal year 1984 level is 10 percent below the fiscal year 1983 operating plan, which in turn is not quite at the fiscal year 1981 level. Following is a line-by-line summary of the space science budget.

PHYSICS AND ASTRONOMY

Space telescope development.—The reduction from fiscal year 1983 to fiscal year 1984 is as expected since the peak development costs are past. ST continues toward a 1985 launch, and promises to be an extremely valuable astronomical observatory.

Gamma ray observatory development.—The increase from fiscal year 1983 to fiscal year 1984 is as expected as peak development costs (in 1985) approach. This important advance in high-energy astrophysics is proceeding toward a 1988 launch.

Shuttle/Spacelab payload development.—The fiscal year 1984 budget level is a 12 percent increase over fiscal year 1983. This level permits continued development of the Solar Optical Telescope (SOT), as well as definition of the Shuttle Infrared Telescope Facilities (SIRTF) two major facilities designed for repeated flights; these are of great value to solar physics and to infra-red astronomy respectively. Also under this budget line are data analysis of Spacelab-1, scheduled for launch in 1983, and continued development of the Spacelab-2 experiments scheduled for launch in 1985 and of three ultraviolet instruments (designated OSS–3) scheduled for launch in 1986 to observe Comet Halley. The line includes $2 million for studies to define potential payloads for a space station. The proposed fiscal year 1984 funding level will permit the start of development of three X-ray astronomy instruments (designated OSS–2) which had been selected but not funded for development in 1979 as a result of the Announcement of Opportunity for Spacelab payloads.

There is a major backlog of other "selected but not funded" investigations for Spacelab which will remain unfunded in fiscal year 1984. Of 29 U.S. experiments of the principal investigator (PI) type (as contrasted to facilities) which were selected in 1979, by December 1982 only 3 (OSS–3) have been funded for development, 13 have received some definition study funding, and another 13 have received no funding.

Explorer development.—The fiscal year 1984 budget requests a significant augmentation of the funding level for this line, from $34.3 million in fiscal year 1983 to $48.7 million in fiscal year 1984. The Explorer program is of great value to space science. Its most recent success was the launch, in January of this year, of the Infrared Astronomy Satellite (IRAS). The Explorer program is of special importance to universities because it provides an ongoing level of support for relatively small, usually PI class spaceflight investigations. This line has been fixed near $30 million for many years, with the result that inflation has forced a long stretch-out of the Explorer program. The proposed fiscal year 1984 augmentation makes a significant step toward restoring the productivity of this program and is responsive to one of the recommendations of the National Academy of Sciences Astronomy Survey Committee. It will permit an fiscal year 1984 start on development of the Extreme Ultraviolet Explorer (EUVE), a university-based, principal investigator experiment. The EUVE was selected for flight as a result of a competitive Announcement of Opportunity seven years ago and has been on hold ever since. We note with approval that the queue of previously selected Explorers has been reduced sufficiently to permit the recent selection of the X-Ray Timing Explorer (XTE) for future development. Definition studies for XTE are funded in this 1984 budget, and a development start is likely in late 1985. The budget also permits continued development of the Active Magnetospheric Particle Tracer Explorer (AMPTE), the Cosmic Background Explorer (COBE), and U.S. instrumentation which fly on the German Roentgen Satellite (ROSAT).

Mission operations and data analysis.—This line in the Physics and Astronomy budget appears to be funded at an adequate level in fiscal year 1984 to support operations and analysis of the IRAS, AMPTE, and International Ultraviolet Explorer (IUE), and extended analysis of data from the High Energy Astronomy Observatories (HEAO). The budget also supports the in-orbit repair and continued operation of the Solar Maximum Mission (SMM), and preparation for Space Telescope operations and refurbishment. The SMM repair mission will provide a valuable extension of this significant solar investigation, as well as the first demonstration of the in-orbit repair capability of the Shuttle.

Research and analysis.—This critical line of the budget shows a $1 million (3.5 percent) increase from fiscal year 1983 to fiscal year 1984. Apparently the fiscal year 1984 proposal carries an inflationary increase of about 10 percent over the proposed fiscal year 1983 budget, ignoring the $2 million which was added to this line as a result of the fiscal year 1983 Congressional action. While this looks like a healthy increase over fiscal year 1982, it must be remembered that the fiscal year 1982 budget was 13 percent below that of fiscal year 1981 in this line. In fact, the proposed fiscal year 1984 budget is only about 13 percent above the fiscal year 1981 budget, certainly not an inflationary growth; and this budget had fallen 15 percent between fiscal year 1979 and fiscal year 1981. The Physics and Astronomy R&A includes three subdivisions: Supporting Research and Technology (SR&T) which funds basic experimental and theoretical research, principally at universities; this part is down $0.5 million from fiscal year 1983. Advanced Technology Development (ATD), is up $1.2 million from fiscal year 1983; this part will principally be used for studies of the Advanced X-Ray Astrophysics Facility (AXAF), a 1.2 m X-ray telescope which was the highest priority in the recent National Academy of Science Astronomy Survey Committee report. Data Analysis of past missions is up $0.3 million from fiscal year 1983.

(*Note.* It is difficult to compare the fiscal year 1984 budget document, which includes figures for fiscal years 1982 and 1983, with earlier documents giving fiscal year 1981 figures because Space Plasma Physics R&A was included in the Physics and Astronomy R&A line in fiscal year 1981 but now appears in Environmental Observations R&A where it is combined with some items that appeared in the suborbital part of Physics & Astronomy in fiscal year 1981. See Table 2.)

Suborbital programs.—This budget line supports aircraft, balloon, and sounding rocket programs which combine with R&A efforts to yield important scientific results at relatively low cost with relatively quick turn-around. These programs are ideally suited for university based research programs, particularly those involved in the training of graduate students. About half of the $5 million (11 percent) increase from fiscal year 1983 to fiscal year 1984 will pay for basic support of the National Scientific Balloon Facility (NSBF) which has been transferred from the National Science Foundation to NASA. While this transfer took effect at the beginning of fiscal year 1983, the full cost was not included in this line of the fiscal year 1983 budget. Aside from the increase for the NSBF, it appears that the fiscal year 1984 budget proposal represents an increase of about 7 percent over the proposed fiscal year 1983 budget, and ignores the $1 million which was added to the sounding rocket program as a result of the Congressional action.

(As with the R&A line, direct comparison of the current budget proposal with fiscal year 1981 levels is difficult because of transfer of the Applications Airborne program into this line. See Table 3.)

PLANETARY EXPLORATION

Galileo development.—The proposed fiscal year 1984 budget includes funding for continuation of the Galileo program, progressing toward a launch in 1986. This program is well past its peak development costs, so this budget line is $19 million lower in fiscal year 1984 than in fiscal year 1983.

Venus radar mapper (VRM).—The President's budget proposes $29 million for a fiscal year 1984 new start of this mission. This is the first planetary new start since that of Galileo in fiscal year 1978. VRM, which has the endorsement of the Space Science Board is a less ambitious exploration of Venus than the Venus Orbiting Imaging Radar (VOIR) mission which had been proposed by NASA a year ago for a new start, but was not included in the President's budget. VRM preserves the principal objective of VOIR, radar mapping of the entire planet, but does so with somewhat lower resolution and without several ancillary observations that had been part of VOIR. The projected runout costs of VRM through fiscal year 1988, the proposed year of launch, are approximately $340 million, compared with roughly twice that for VOIR. VRM is an extremely valuable step in planetary exploration which will have the active participation of a number of university scientists.

International Solar Polar Mission (ISPM).—The fiscal year 1984 budget continues to fund the US experimenters on the European ISPM spacecraft which is also scheduled for 1986 launch.

Mission operations and data analysis.—The proposed level of $43.4 million, up 13 percent from the fiscal year 1983 operating plan, appears to be adequate for operation of the Pioneer and Voyager spacecraft, which had been threatened with termination by the President's fiscal year 1983 proposal and were saved by Congressional action. It also includes funds for development of systems needed for operation of Galileo and ISPM.

Research and analysis.—Here we have a continued serious erosion of the science base upon which the planetary program rests. The proposed fiscal year 1984 level of $45.5 million is 10 percent lower than the fiscal year 1981 level of $50.7 million. While this is not as damaging as the 30 percent cut which had been proposed a year ago for fiscal year 1983, it is still a drastic reduction when 3 years' inflation is considered. While the fiscal year 1984 proposed level is $10 million higher than the President's fiscal year 1983 proposal, it is nearly $5 million lower than the actual fiscal year 1983 operating plan which resulted from Congressional action on the fiscal year 1983 budget. This 10 percent cut is distributed almost uniformly over all the planetary R&A components except for the Halley's Comet program which remains at $2.2 million in fiscal year 1984, the same as fiscal year 1983.

ENVIRONMENTAL OBSERVATIONS

Research and analysis.—R&A in Environmental Observations includes programs in upper atmosphere, atmospheric dynamics, oceans, and space plasma physics. The space plasma physics part was previously included in the Physics & Astronomy R&A, (see Table 2) and this part is seen as space science while the other aspects of the Environmental Observations program are more directed toward space applications. Fiscal year 1984 shows modest growth in these lines from fiscal year 1983. One item of concern to the space plasma physics community is the relatively low priority in Environmental Observations on definition of the mission Origin of Plasmas in the Earth's Neighborhood (OPEN) for which experimenters were selected two years ago. This mission had enjoyed higher priority when space plasmas were part of Physics and Astronomy. The Advanced Technology Development (ATD) portion of this R&A line which includes funding for OPEN definition drops from $3.5 million in fiscal year 1983 to $1.8 million in fiscal year 1984, resulting in serious cuts for the definition efforts of experimenters who have been selected for this mission.

Upper Atmosphere Research Satellite (UARS).—Development of experiments for this mission continues but the fiscal year 1984 budget does not permit a start of the spacecraft development. It is hoped that this new start will occur in early 1985. UARS will provide the first global measurements of stratospheric and mesopheric ozone, chemical species that affect ozone, energy inputs, temperatures and winds.

TABLE 1.—SPACE SCIENCE IN THE NASA OSSA BUDGET

[In millions of dollars]

	1981	1982	1983	1984
Total NASA	5,425.6	6,020.0	6,839.4	7,106.5
Total research and development	4,334.3	4,772.0	5,542.8	5,708.5
Total space science and applications	873.0	896.2	1,034.1	1,068.0
Total physics and astronomy	323.7	322.4	441.0	514.6
Space telescope development	119.3	121.5	137.5	120.6
Gamma ray observatory	8.2	8.0	34.5	89.8
Shutle/Spacelab	27.4	47.6	83.0	92.9
Explorer development	33.3	33.3	34.3	48.7
Mission operations and data analysis	38.9	45.3	74.8	79.5
Research and analysis	[1] 37.7	22.9	28.8	29.8
Suborbital	[1] 30.9	43.8	48.1	53.3
Total planetary exploration	175.6	210.0	186.4	205.4
Galileo	63.1	115.7	91.6	79.5
Venus radar mapper				29.0
International solar polar	[2] 28.0	5.0	6.0	8.0
Mission operations and data analysis	61.8	42.6	38.5	43.4
Research and analysis	50.7	46.7	50.3	45.5
Total life sciences	42.2	39.5	55.7	59.0
Flight experiments	12.7	14.0	24.0	23.0
Research and analysis	29.5	25.5	31.7	36.0
Total solid Earth observations	151.4	149.4	132.2	74.4
Landsat-4	88.5	81.9	61.7	15.8
Extended mission operations		2.8	1.8	1.0
Shuttle/Spacelab	2.0	12.3	13.8	15.0
Geodynamics	23.4	22.9	26.2	28.0
Agristars	21.5	14.0	15.0	
Research and analysis	16.0	15.5	13.7	14.6
Total environmental observations	104.1	133.0	156.9	163.0
Research and analysis (less space physics)	76.8	(59.7)	(71.2)	(76.2)
Upper atmosphere		20.5	27.7	29.6
Atmosphere dynamics		22.3	26.5	28.4
Ocean		16.9	17.0	18.2
Space physics (plasmas)	(3)	12.1	15.2	15.7
Shuttle/Spacelab	1.7	4.1	3.7	7.6
Operational statellite improvement		6.0	6.0	0.6
Earth radiation budget	20.3	24.0	24.0	15.5
Extended mission operations		16.1	22.4	27.4
Upper atmosphere research satellite		6.0	14.0	20.0
Other	5.3	5.0		

[1] These two lines did not include the same items in fiscal year 1981 as in later years and so fiscal year 1981 numbers are not directly comparable. See tables 2 and 3.

[2] In fiscal year 1981 ISPM was in the physics and astronomy program, and included a U.S. spacecraft (since deleted) in addition to U.S. experiments on a European spacecraft.

[3] In fiscal year 1981 environmental R&A did not include space physics, which was in pysics and astronomy R&A (See table 2).

TABLE 2

	1981	1982	1983	1984
Physics and astronomy R&A	37.7	22.9	28.8	29.8
Space physics sounding rockets	2.5	([2])	([2])	([2])
Environmental observation: Space physics (plasmas) R&A	([1])	12.1	15.2	15.7
Total	40.2	35.0	44.0	45.5

[1] Space physics (plasmas) R&A was included in physics and astronomy in fiscal year 1981.

[2] The space physics (plasmas) part of the sounding rocket section of the suborbital physics and astronomy line in fiscal year 1981 was transferred to environmental observations R&A for fiscal year 1982, 1983, 1984 budgets. This part was $2.8 million in fiscal year 1983, $2.5 in fiscal year 1982, and estimated at approximately $2.5 million in fiscal year 1981.

TABLE 3

	1981	1982	1983	1984
Suborbital physics and astronomy sounding rockets (less space physics, see table 2)	22.5	24.4	27.0	27.7
Airborne [1]	4.5	17.5	17.6	18.9
Balloons	1.4	1.9	3.5	6.7
Applications airborne	12.0	([1])	([1])	([1])
Total suborbital	40.4	43.8	48.1	53.3

[1] Applications ariborne included in physics and astronomy starting fiscal year 1982. $12 million is estimated as the number for this item in fiscal year 1981.

APPENDIX B

Comments on the U.S. Space Science Situation

The opening sections of the OTA Technical Memorandum [1] on space science give a brief survey of the many different aspects of space science. Then the memo goes on to say that planetary science is in real trouble because there are no new missions so that the scientists active in that field are without funds and without a future. They will soon be forced to turn to other things. And that is a fairly accurate picture of planetary science. But the memo stops at that point, leaving the impression that the other branches of space science surveyed in the opening sections are alright.

As a matter of fact, most branches of space science in the U.S. face a bleak future. To illustrate a typical situation, solar physics can look forward to perhaps 12-15 months of new data at solar minimum following the repair of the Solar Maximum Mission (SMM). The Interplanetary Solar Polar Mission was to have been launched in 1984 for a look at the Sun—and conditions emanating from the Sun—at high latitudes, where no spacecraft has ventured before. But the U.S. spacecraft carrying the coronagraph was cancelled and the U.S. launch of the European spacecraft was postponed to 1986—so that the mission is far less effective than originally planned and so far in the future that the U.S. research groups—even if they are participating on the European spacecraft—are disbanding for lack of support. The Solar Optical Telescope (SOT) is going ahead at a slow pace now, with a launch tentatively planned somewhere around 1988, assuming that there are no further delays in funding. The much touted opportunities for observations from Shuttle have not materialized—leaving the field of solar physics with little more than 12 months of SMM data for the rest of the decade. The fact that there are many crucial observations to be performed, as elaborated by intensive study and planning reports over the past six or eight years, seems to carry no weight. The space missions fade away as their time approaches.

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[1] Space Science Research in the United States: A Technical Memorandum by the Cogressional Office of Technology Assessment" (September, 1982).

Turning to magnetospheric physics, we can look forward to the Chemical Release Experiments of the AMPTE Mission, expected to be launched in 1984 in which a German spacecraft outside the magnetosphere is to releazse chemicals to be detected by the instrumentation on a U.S. spacecraft located inside the magnetosphere, giving direct measurements of the rate of entry of solar wind gases into Earth. But there is no real U.S. commitment beyond that. The OPEN Missions to study plasma waves, etc., in the magnetosphere and surrounding solar wind are moving along with a launch tentatively planned for 1991 or 1992, perhaps. The Shuttle and associated Spacelab experiments have not materialized. it may be ten years before there is a new mission. It is just not possible to keep good physicists interested in space experiments when the future is so far away and so uncommitted.

The field of X-ray astronomy looks forward to flying a less expensive version of the HEAD–II X-ray telescope on the German X-ray spacecraft to be lauched in 1986. The X-ray Timing Explorer (XTE) at about the same time is the only new U.S. mission firmly in the pipeline. The large, high resolution X-ray telescope, Advanced X-ray Astrophysics Facility (AXAF) is only a dream that could not materialize before 1990, at the earliest. The initiatives are passing to the Japanese and the Germans, who have committed themselves to four X-ray space missions in the coming years. It is ironic that the United States, having brought the science of X-ray astronomy to a peak with HEAO–II, should now sit back, unwilling to commit capital, while other nations press on from the summit that we established by an investment a decade ago in our own space science. As in the other fields already cited, the X-ray community is frustrated year after year by a refusal of the United States to commit itself to new missions. Shuttle opportunities, once presented in glowing terms to the scientific community, have failed to materialize. Postponement into the next decade is the word of the day, which leaves a strong doubt that the field will go ahead in the United States at any time in the foreseeable future.

In the field of gamma-ray astronomy, France and the U.S.S.R. have cooperative plans for an orbiting gamma-ray observatory, to be launched some time in 1983–84. It will be a simple affair, but capable of doing some interesting science. The U.S. Gamma-Ray Observatory (GRO) will take a more precise and detailed look at the gamma-ray sources in the sky, but it has now been pushed back to a tentative launch in 1987–89, at the end of the decade. It is not clear how one can sustain interest and scientific capability in the interim, particularly when the scientific community is aware that a further delay in the launch of the U.S. GRO may come with any new annual budget cycle, as have the endless delays in the past.

Taken together, these plans do not add up to much for space science in the United States in the next 10 years. Three or four missions among as many different fields of inquiry in a 10-year period are not effective for getting at the crucial issues. All of the major fields of space science are focused on important discoveries and critical issues in the active universe around us. Progress in each subject is paced by observations from spacecraft. Each subject is propelled by the vigor and enthusiasm and past successes of a small group of U.S. scientists. If the United States does not have some new starts and rapid progress in space missions in the very near future, U.S. space science will wither away. Space science will pass into the hands of other countries with more vigorous and determined approaches (Germany, Japan, France, U.S.S.R.). Not a word of this, beyond planetary science, is to be found in the OTA memo.

Another point is that the memo presents the annual budget for NASA space science, (Figs. A–2, A–3, A–4) showing the general downward trend over the years and small upturn at the end for 1983. The figures make the point, but it should be emphasized that the small upturn for 1983 reflects the delay of launch dates, particularly SOT, Galileo and the Space Telescope. The actual money going directly into scientific research outside NASA is not larger in 1983 than in previous low years. U.S. scientific teams are in the process of disbanding today because the launch dates for the spacecraft with which they are concerned have been pushed so far in the future that: (a) the dates are not always believable; and (b) the support for the teams has been turned off by NASA to save money in the interim.

A willingness to make major capital investments in the future is as essential for effective space science as it is for most other serious activities. Short term policies, based on monetary political winds, make effective science impossible. It was the NASA investment in the sixties and early seventies that placed our country in the prestigious position of number one in space and in space science. Unfortunately, the causes of our success were not perceived in all quarters, so that the late seventies and the first 2 years of the eighties saw: (a) little or no new investment; (b) an unwillingness to support the continued operation and analysis of the scientific space missions built with earlier investments; and (c) a tendency to reverse policies every 12 months.

The result is that the United States has dropped out of most fields of space science for the rest of the eighties. Worse, the stochastic policies of the past few years have created a credibility gap. The scientific community has learned that no matter how well conceived, no matter how far along, and no matter how internationally based, a space mission can be cancelled at any point at the blink of an eye. One has to remember that the motivation for scientists to contribute their time and effort to a space mission is not monetary profit, but scientific success. And scientific success requires a firm commitment to go ahead with space missions.